BREWING OPERATIONS.

INTRODUCTORY.

In the following are given the principles and methods of brewing, as they are understood and recommended by the American Brewing Academy, as well as the Scientific Station for Brewing of Chicago. The matter is presented in a very concise manner, in accordance with the plan of this book, refraining from all discussions and omitting all subjects that do not appear to have practical significance. Readers will find in other parts of the book matters pertaining to Brewing Science, theoretical, historical and explanatory.

As far as Brewing Operations are concerned it seemed to the publishers essential to have the subject treated from one standpoint, so as to avoid confusing the reader, who is not supposed to study this part with a view of drawing his own conclusions, but rather of obtaining advice. If, therefore, statements are made which, in the light of the present status of brewing science, must be considered to be still in doubt, the reader will remember the reasons that prompted an avoidance of discussion at the respective place. For the same reasons it was found undesirable to make extensive mention of literature in this part of the book.

GENERAL OUTLINE.

Brewing Operations, properly so-called, embrace the production of the wort from the raw materials. They include all the operations from the scouring or cleaning of the malt up to the point when yeast is added to the finished wort in the settling tank or the fermenting vat.

Before selecting and weighing the materials, in order to start brewing operations, the brewer should clearly understand the requirements the finished product is to meet, and every operation

he carries out should be undertaken with a knowledge of the influence it may have in shaping the character of the beer as desired.

Beers as we find them in the market vary greatly as to their properties. We may distinguish, for instance:

1. The *Bavarian* type of lager beer, with a dark color, malt flavor, and a sweetish taste as the main features, with the aroma and bitter taste of hops but little pronounced; usually lively and sparkling.

2. The *Bohemian* type of lager beer, with a light color, pronounced hop aroma, and bitter taste; while the malt flavor is not pronounced; usually lively and sparkling.

3. The *American* type of lager beer, with a light color and pronounced hop aroma; less bitter than the Bohemian, with a high degree of brilliancy; quite lively and sparkling.

4. *Ale,* with a light color, very pronounced hop aroma and bitter taste, and with a rather high percentage of alcohol and tart taste in the aged product, either lively or still, and usually clear.

5. *Stout,* with a very dark color, malt flavor and sweet taste, brewed stronger than ale, and possessing a tart taste in the aged product, but less alcohol than ale; usually lively.

6. *Weiss beer,* very light in color, no pronounced malt or hop flavor, quite tart, very lively, but not sparkling; usually turbid.

7. *Common or Steam Beer,* light in color, hop aroma and bitter taste not very pronounced; very lively and not necessarily brilliant.

The American, Bohemian and Bavarian types of lager beer should possess a certain degree of palatefulness, and should draw with a creamy, lasting head, which requirements are not to the same extent to be met by the other brands.

Besides the above there are brewed in America beers to meet special requirements, for instance:

Temperance beers, so-called; bottled goods, with a percentage of alcohol less than 2 per cent. Such beers are considered non-intoxicating, and are not excluded from the market in so-called temperance districts.

Tonics, so-called: Bottled goods brewed with a high percentage of extract, usually pure malt beers, possessing a dark color, either thoroughly fermented with a high percentage of alcohol and comparatively low percentage of remaining extract, or imperfectly fermented, with a low percentage of alcohol and high percentage of remaining extract.

The selection of the methods to be employed to produce beer should be made from the point of view of quality, that is, character, of the finished product, and from the view point of economy.

PROPERTIES OF A BEER.

The character or properties of a beer are necessarily dependent upon its composition, that is, upon the amount and nature of certain substances contained in the beer, and although we may not as yet be able to account chemically for every peculiarity of character a beer may possess, it seems justifiable to express the well-known properties of beer in terms of concrete chemical substances.

Such properties of beer are:

"Palate-fulness (body)," dependent upon the relative amounts of extractive matter, especially albuminoids (albumoses, peptones, amides).

"Foam-holding capacity," dependent on a definite amount of carbonic acid gas, and on the same substances that give palate-fulness.

"Life," dependent on amount of carbonic acid.

"Color," dependent on amount of caramel.

"Malt Flavor," also dependent on amount of caramel.

"Hop Flavor," dependent on amount of hop-oil.

"Taste:" "Bitter," dependent on amount of hop resin; "sweet," on amount of sugar (kraeusened beers) and malto-dextrin; "tart," on amount of lactic acid; refreshing taste, on amount of carbonic acid.

"Stimulating effect" on consumer, dependent on amount of alcohol.

"Brilliancy," by which we mean the property of a beer of being transparent. Brilliancy may be impaired by particles in suspension, which may consist of either complete organisms or organic matter. The former may be either yeast cells, and in that case culture yeast, wild yeast, or mycoderma; or, bacteria, under which head come sarcina, lactic acid ferments, butyric acid ferment, acetic acid ferment, saccharobacillus pastorianus. The organic matter may consist of starch, albuminoids, or hop resin. Inorganic matter is found in rare instances as a cause of turbidity.

"Durability (stability)," by which we mean the property of a beer of retaining its character after it is finished. This property may suffer from yeast cells, bacteria, or albuminoids, or any condition favorable to the growth of yeast or bacteria, like presence of sugar, or storing at high temperatures. It is enhanced by the amounts of alcohol, carbonic acid, lactic acid, and hop-resin, which have the force of natural preservatives.

COMPOSITION OF BEER.

The substances that make up beer, varying in ratio according to the character of the beer, are:

Non-volatile: 1. Albuminoids, divided into albumoses, peptones, amides, all of which are desirable, and proteids, which are undesirable. 2. Carbohydrates, as dextrin, malto-dextrin, maltose. 3. Miscellaneous bodies, as lactic acid, mineral substances, hop-resin, and caramel.

Volatile: Alcohol, carbonic acid, water and hop-oil.

BEERS CLASSIFIED.

The composition of a beer is dependent upon the composition of the wort from which it has been produced, on the method employed in fermentation, and on the treatment of the beer after fermentation. According to the system of fermentation employed, beers may be classified as follows:

1. BOTTOM FERMENTATION.

a. *Pilsener* ....
b. *Wiener* .... } German Lager Beers.
c. *Muenchener* ....
d. *American Lager Beers.*
e. *American Steam Beers.*

2. TOP FERMENTATION.

f. *Ale* ....
g. *Porter* .... } English Beers.
h. *Stout* ....
i. *Weiss Beer.*

3. SPONTANEOUS FERMENTATION.

j. *Lambic* .... } Belgian Beers.
k. *Faro* ....

The influence of the system of fermentation on the composition of the beer becomes noticeable, especially in the different quantities of lactic acid produced during fermentation and storage.

Bottom fermentation beers have less lactic acid and fewer bacteria than top fermentation beers, these, in turn, have less than spontaneous fermentation beers.

WORT.

The term "wort" is applied to the fluid produced by the process of brewing proper from the raw materials and before its transformation into beer by fermentation. As to where the fluid ceases to be wort and begins to be beer, no hard and fast line has been established. The materials from which the wort is made are malt and malt adjuncts, hops and hop preparations, and water.

INGREDIENTS DERIVED.

The ingredients of the wort are derived as follows:

Dextrin, Malto-dextrin, Sugar	from starch by action of diastase	Enzymes generated in barley by malting.
Amides, Peptones, Albumoses, Proteids	from albumen of malt by action of peptase	Enzymes generated in barley by malting.
Caramel—formed from sugar in kiln-drying of malt.		Extracted by water.
Lactic acid—formed during germination by action of lactic acid ferment and at low temperature in mash.		Extracted by water.
Mineral substances—from malt or adjuncts to malt.		Extracted by water.
Hop oil, Hop resin	from hops.	Extracted by water.

PRINCIPLES OF MASHING.

Mashing is the process of extracting the goods by mixing them with water at suitable temperatures and in proper relative quantities, preparatory to boiling in the kettle.

Chemically, it proceeds in the main by the inversion of the starch into maltose, malto-dextrin, and dextrin, and the modification of the insoluble albuminoids into a soluble form. These changes are brought about by the agency of two substances which are contained in the malt, and begin operations when the malt is mixed with water at definite temperatures.

These substances are called diastase and peptase. They were formerly called chemical ferments as distinguished from the organic ferments which are responsible for fermentation. At the present day the term enzymes, or soluble ferments, is more commonly applied to them. It is the function of the diastase to invert the starch, of the peptase to modify the albuminoids of malt as above indicated.

The amounts, both absolute and relative, of dextrin, malto-dextrins and maltose, as well as of the modified albuminoids like albumoses, peptones and amides, finally present in the wort, are materially affected by the conditions under which the enzymes do their work. Hence, it is in the power of the brewer to control the composition of the wort, within certain limits, by modifying such conditions.

DIASTASE AND STARCH.

(See also Chemistry.)

Diastase is a body having many properties in common with vegetable albumen of the type of proteids. It is readily soluble in water. A solution heated to 178° F. (65° R.) precipitates, like proteids, flakes of albumen, the diastase coagulates and loses its power of inverting starch. A solution of diastase, upon being introduced into starch gelatinized by heating in water, liquefies the starch, and then inverts it into dextrin, malto-dextrins, and sugar. Inversion is most rapid between 122° and 140° F. (40° to 48° R.). As the temperature rises up to 167° F. (60° R.), the inversion of starch proceeds more slowly, its action practically ceasing at 178° F. (65° R.), the ratio of sugar declining, and that of dextrin increasing above 140° F. (48° R.).

Below 122° F. (40° R.) the energy of diastase declines more and more, but remains to some extent even at 32° F. (0° R.). This fact is utilized for the purpose of clarifying beers in case of starch turbidity by adding malt extract.

Diastase acts but slowly on starch that has not been gelatinized. Gelatinization must therefore precede inversion.

GELATINIZATION OF STARCH.

Starch being mixed with water, and the mixture heated, at a certain temperature the starch granules begin to swell and finally burst, and a gelatinous mass or starch-paste results. For crushed malt, this process goes on rather slowly in the mash at temperatures between 122 and 144° F. (40-48° R.), and more rapidly as the heat approaches 167° F. (60° R.), while it is quite insignificant under 100° F. (30° R.).

RULES FOR GELATINIZING STARCH.

The following general rules can be given for the gelatinization of starch when brought together with water.

1.—The higher the temperature, the more quickly will the starch gelatinize. In boiling water (212° F.) the starch will gelatinize, for instance, more quickly than in water of 167° F. (60° R.), and in water of 250° F. (97° R.)—when heated under pressure—more quickly than at the boiling point.

2.—The more finely divided the starch, the more quickly will it gelatinize. Corn meal will gelatinize more quickly than coarse grits at the same temperature; corn flour more quickly than corn meal.

3.—The more flinty the starch, the slower will it gelatinize. The starch in crushed malt will gelatinize more quickly than the starch in corn meal of the same degree of fineness, the starch in corn meal being more flinty.

In malt we have the starch, generally speaking, in different degrees of mellowness and fineness. Some of this starch will be readily soluble at comparatively low temperature, i. e., between 122 and 144° F. (40-48° R.), while the coarser and more flinty particles need higher temperatures for gelatinization; the diastase acting practically only upon gelatinized starch. The time required for complete inversion of the starch depends upon the rapidity of gelatinization and upon the energy of the diastase at certain temperatures. Thus, although at 133° F. (45° R.), the energy of the diastase is very great, the diastase inverting the gelatinized starch almost instantaneously, complete inversion is not so quickly attained, in a malt mash, for instance, at this temperature, as it is at 167° F. (60° R.), where the energy of the diastase is greatly diminished, but the rapidity of gelatinization much increased.

The time required for the complete inversion of the starch in a malt mash, when kept at certain temperatures, has been found to be:

At degrees F.	100	122	140	149	158	167	176
At degrees R.	30	40	48	52	56	60	64
Time for complete gelatinization and inversion in hours	No complete inversion obtained.	24	6	1	¾	1	2

The time will, of course, vary with the character of malt, no two mashes giving exactly the same figures.

When holding corn meal at various temperatures, gelatinization has been found to proceed as follows:

At degrees F.	30	122	150	190	212	300
	none.	very slow.	slow.	more rapid.	rapid.	very rapid.

INFLUENCE OF DIASTASE ON GELATINIZED STARCH IN RESPECT TO PRODUCTS FORMED.

Diastase acting upon gelatinized starch transforms or inverts this substance into other products, of which the important ones are the different forms or types of

Dextrins,
Malto-dextrins,
Sugars.

DEXTRINS.

(See also "Chemistry.")

The "amylo-dextrin" and "erythro-dextrin" are undesirable. They are not soluble at low temperatures and give rise to so-called starch turbidities when present in the beer.

The desirable type among dextrins is the achroodextrin, which is the one commonly designated as dextrin.

The dextrins are practically unfermentable by culture yeast, and are found in the extract of the beer in the same amount as contained in the wort.

SUGARS.

Of the different types of sugars contained in wort, the one known as "maltose" is the most important. Besides this, small amounts of saccharose (ordinarily termed cane sugar) and dextrose (ordinarily termed grape sugar) and levulose (ordinarily termed fruit sugar) are also present.

All these sugars are readily fermented. Their amount determines the percentage of alcohol in the fermented beer, and the degree of fermentation.

MALTO-DEXTRINS.

The malto-dextrins represent substances that may be considered as in a state of transition from the dextrins to maltose. They do not ferment with the same facility as the sugars, and are not found in the fermented beer in their entire quantity like the dextrins. They are called the "not readily fermentable" sugars. Some species of yeast, the so-called high-fermenting types, ferment these malto-dextrins more readily than others, the so-called low-fermenting types.—(See also "Yeasts and Fermentation.")

PROPORTIONS OF DEXTRIN, MALTOSE AND MALTO-DEXTRINS.

According to the conditions under which inversion takes place, which are mainly those of temperatures and periods of action, the proportions of these different carbohydrates to each other may vary considerably.

At temperatures where the diastatic energy is not weakened there is a tendency to form more maltose and less dextrin than at temperatures where the diastatic energy has become affected by high heats. Thus below 140° F. (48° R.) the proportion of maltose to dextrin is greater than above 140° F. (48° R.), and the higher the temperature is selected for inversion above 140° F. (48° R.), the greater will be the relative amount of dextrin.

The diastase continues to act on the dextrins and malto-dextrins already formed, changing them to maltose. The longer the mash is held at certain temperatures, the greater will be the amount of maltose in proportion to the amount of dextrin.

The absolute amount of dextrin formed may approximate that of the maltose, but is never found to be higher under the conditions obtaining in the brewery.

The relative amounts of sugar and non-sugar found in the mash, when the mixture of malt and water is held at certain temperatures until inversion is complete, is about as follows:

At degrees F......	100	122	140	149	154	158	163	176-178
At degrees R......	30	40	48	52	54	56	58	64- 65
Ratio of sugar to non-sugar 100:..	20	20	20	40	50	60	70	100
Or percentage of sugar in extract..	83	83	83	71	67	62.5	59.8	50

In carrying out the mashing process, therefore, we must consider:

1. That under 100° F. (30° R.), but little starch of the malt is gelatinized.
2. That above 150° F. (52° R.), the starch of the malt is gelatinized rapidly.
3. That below 100° F. (30° R.), little sugar or dextrin is formed.
4. That between 122° F. (40° R.) and 140° F. (48° R.), much sugar and little dextrin is formed.
5. That above 150° F. (52° R.), less sugar and more dextrin is formed than between 122 and 140° F. (40 and 48° R.).
6. That unmalted cereals, containing starch in a flinty state, must be boiled to gelatinize the starch.

PEPTASE AND ALBUMEN.

(See also "Chemistry.")

The action of this enzyme lies in the direction of making soluble those albuminoids which are insoluble in the ordinary state. It acts only upon the albumen of malted cereals, develops the greatest efficiency at about 100° F. (30° R.), and declines in strength when the temperature rises above 133° F. (45° R.):

At degrees F...	32	55-77	100-133	145-158	158-212
At degrees R...	0	10-20	30-45	50-56	56-80
	very slow.	more rapid.	very rapid.	slower.	no action.

SOLUBLE ALBUMINOIDS.

The soluble albuminoids produced by peptase may be classified as proteids, albumoses, peptones and amides, although there must be conceded to be a number of intermediate products.

PROTEIDS.

The proteids are not desirable in wort, and should be eliminated therefrom as far as practicable. The hazy appearance of the wort when running from the mash tub is mostly due to proteids. They are only partially eliminated by boiling the wort, a haze generally, and a strong turbidity sometimes, becoming noticeable when the wort is reduced to the temperature for starting fermentation.

The nature of the proteids found in wort and beer shows considerable differences. From 100° F. (30° R.) to 133° F. (45° R.), proteids are formed that are precipitated easily in the kettle and storage vat, and produce good hot and cold "breaks." The higher the temperature above 133° F. (45° R.) at which proteids are formed, the less desirable their nature. A wort that breaks well after cooling to 35° to 40° F. (3° to 4° R.), or filters clear at that temperature, retains but small amounts of undesirable proteids.

In the finished beer a haze sometimes appears at low cellar temperatures, which vanishes when the temperature is raised; or the beer runs clear at the racking bench and develops a sediment in the bottle after pasteurization. In both cases the cause is in the proteids if the beer is otherwise sound and properly treated.

PEPTONES, AMIDES AND ALBUMOSE.

Albumose, peptones and amides are called desirable albuminoids. They lend foam-holding capacity and palate-fulness, or body, to the beer, especially the amides to a marked degree, the latter supplying also nourishment for the yeast, while the peptones are not readily taken up by the yeast, and the albumoses do not furnish it with any nourishment.

Of the total amount of albuminoids contained in the wort, about 25 per cent or one-quarter is taken up by the yeast under ordinary conditions of fermentation.

Holding the mash at a low temperature—below 133° F. (45° R.)—promotes the formation of desirable albuminoids, whereas a higher initial mashing temperature—not to exceed 167° F. (60° R.)—diminishes the amount of desirable albuminoids and correspondingly increases the amounts of the undesirable proteids.

MASHING METHODS AND CHARACTER OF BEER.

The method of mashing to be followed is determined by the requirements as regards the character of beer, etc., and an intelligent selection of the method to be adopted in order to obtain the desired result can be made only with a full understanding of the principles above laid down.

If it is desired to obtain a beer with a high degree of palate-fulness and foam-holding capacity, the brewer must understand how to incorporate in the wort the desirable albuminoids and unfermentable extractive substances on which these properties depend, at the same time avoiding the undesirable albuminoids where durability is an additional requirement.

This can be done by peptonizing at low temperatures, for instance, 100° F. (30° R.), for one hour, and inverting the starch at higher temperatures, for instance, between 154 and 167° F. (54 and 60° R.), in 30 minutes, and raising the temperature rapidly between 100° F. (30° R.) and 154° F. (54° R.) in 20 minutes to avoid the formation of too much maltose.

If we wish to obtain beers with a very low percentage of alcohol, and a very high percentage of extract, we can do so by starting the mash with a temperature above 154° F. (54° R.) if we do not at the same time require the albuminoids for palate-fulness, etc. If we wish to obtain beers with a high percentage of alcohol, we should hold the mash long enough between 122 and 140° F. (40 and 48° R.), at which temperature maltose is mainly produced.

ECONOMY.

The selection of the proper brewing methods should not be governed altogether by the composition of wort and quality of beer to be produced, but due regard should be had to economy of operation. Especially should it be the endeavor of the brewer to minimize any and every waste, be it of materials, coal or labor.

By waste of material is meant the loss occasioned by insufficiently extracting the materials, especially malt and cereals, thereby allowing too much of the valuable constituents to remain in the grains.

By waste of coal in this connection is meant the loss occasioned by adopting unscientific methods of brewing that call for an excessive expenditure of heat, for instance, boiling the brewing water or the wort longer than necessary, or cooling the wort before the addition of yeast to an excessively low temperature.

TO OBTAIN A HIGH YIELD.

In order to keep down the waste of malt and cereals, the most perfect yield possible ought to be obtained from the materials. Three different operations are essential to accomplish this result:

1. To prepare the starch and the albumen for inversion as completely as possible.
2. To invert the starch and albumen, so prepared, as completely as possible.
3. To extract the grains as completely as possible.

In fulfilling the first requirement, viz., the preparation for inversion, it should be borne in mind that the albumen can be made invertible only by the process of germination of the grain. The starch can be made invertible by the following means and processes:

1. Malting (cereals, especially barley).
2. Crushing (malt).
3. Rolling (cereals with mealy endosperms or starchy part, especially wheat).
4. Grinding (corn, rice).
5. Boiling (corn, rice, flinty malt).
6. Boiling under pressure (corn).
7. Steaming and rolling (corn, by which method corn flakes are produced).

With regard to the second requirement for a perfect yield, viz., the complete inversion of the prepared starch and albumen, it is to be said that inversion should take place in the mash tub at 100-133° F. (30-45° R.) for albumen and 153-167° F. (54-60° R.) for starch.

With regard to the third requirement for a perfect yield, viz., the complete extraction of the grains, this is done by washing out the extract with water (sparging). In order to extract the grains most completely it is necessary to reserve as much water for sparging as possible. Generally the brewer should be able to reserve at least one-half of the water employed for the brew for this purpose.

MASHING OPERATIONS.

The mash should be so conducted as to secure the desired composition of the wort and obtain the largest possible yield of extract from the goods employed.

With respect to securing the desired composition, the conditions which control the ratio of sugar to dextrin and the production of desirable albuminoids should be observed.

With a view of obtaining the full yield which the goods can afford, it is necessary to prepare for inversion, and invert, the starch in the brewing materials, and to wash out the grains, most completely.

It is with an eye to these requirements that the malt should be prepared so as to possess a proper degree of mellowness and friability and no vitreous or flinty quality. Such a malt will afford the mash liquor ready access to all its parts, subjecting them to the action of the enzymes.

The same purpose is served by crushing or grinding the malt, which is always done before running it into the mash-tun. The more mellow the malt, as to consistency, the less fine need the grist be, and, on the other hand, the less mellow the malt, the finer should the grist be.

Where the degree of mellowness is quite low, the crushed malt may with profit be prepared in the rice cooker, with or without raw grain, as it is apt to give rise to difficulties of drainage if put into the mash without preparation. Any malt should be so ground that every single grain is crushed, but not so as to become pulverized.

Care should also be taken to remove all the sprouts since they contain many undesirable proteids.—(See "Cleaning Malt" in "Malt House Outfit.")

MASHING SYSTEMS.

Different methods of applying temperatures to a mash supply the following systems:

1. Infusion or water mash:
   - American Malt Beers.—From lower initial temperature to higher final temperature.
   - English Beers.—High initial temperature.
2. Decoction or Thick Mash.—German beers.
3. Double Mash.—American raw cereal beers.

By the infusion method, the mash is brought to its final temperature by the admixture of water of suitably high temperature. By the decoction method, part of the mash itself is raised to a boil and then returned to the mash-tun. By the American raw cereal mash the raw grain is boiled separately and run into the malt mash to produce the final temperature.

Malt contains diastase in quantities sufficient to convert into maltose more starch than that which is stored up in the malt itself. This fact, which was known for many years, naturally led to efforts to put this valuable substance to practical use. Brewing experts, among them Balling, years ago utilized the excess diastase in malt for the purpose of converting the starch of unmalted grain, or raw cereals, into such materials as were useful to brewers, but owing to legal restrictions the utilization of unmalted cereals never acquired any importance in Germany.

American malts on an average possess a much greater diastatic strength than German malts, in fact, their power in this respect is so great that there is danger of carrying saccharification too far, if the mashing temperatures that are customary in Germany were retained. Hence, the principles of raw cereal brewing became the subject of closer study in this country.

INTRODUCTION OF RICE AND CORN.

It was Anton Schwarz who first advised the employment of rice and subsequently of Indian corn, which is so abundant in this country. The stubborn perseverance with which he sought to convert the conservative brewers to his ideas and finally succeeded in so doing and, last, not least, the discovery of suitable methods for scientifically applying them, entitle him to be called the founder of raw cereal brewing in the United States.

The method suggested by him was based upon the plan of doughing-in the raw grain with a little malt in a separate vessel, making the starch of this raw cereal as nearly as possible entirely soluble by boiling, and running this mash into the malt mash, thereby raising the temperature of the latter to the desired degree, and utilizing the excess diastatic strength of the malt for the complete inversion of the starch in the raw cereals.

It was soon discovered by the brewers that the use of raw cereal adjuncts not only gave a paler color, greater stability and other valuable properties to the beer, but also enabled beers to be produced more cheaply, and its adoption speedily became general. Schwarz never advised using too much raw cereal, but rather opposed it. One-third of the materials figured for malt seemed to him quite sufficient, for with this wise restriction no injurious change in taste need be feared. He also successfully opposed the erroneous opinion that raw cereal worts required more hops than all-malt worts, whereby the saving would be about neutralized.

In 1881 Siebel wrote a treatise (Verbrauen von Rohfrucht, Western Brewer, 1881, page 1463) on the employment of malt adjuncts, like corn, rice and sugar, from which it appears that the methods then employed in the treatment of corn remained subsequently practically unchanged until the introduction of the pressure cooker.

PREPARED CORN.

The increase in plant from the necessity of having two mash tubs was met by preparing the corn by steaming, rolling, etc., so that it was readily convertible in the mash-tun. This led to the introduction of corn flakes, first among which was "Cerealine." It cannot be denied that there are advantages in using these goods, which can be added directly in the mash-tun, especially in small breweries having only one mash-tun (see also "Mashing Operations").

In 1887 the United States Brewers' Association offered a prize for a pamphlet describing the known methods of raw cereal brewing, pointing out the best ones and giving reasons for recommending them, the rapid development of the matter having given rise to a need of throwing light on some of the less suitable methods. The task was performed satisfactorily by A. Weingaertner, who kept within the limits of the prescribed subject, which re-

quired a criticism of existing methods, and only adding that where the taste and odor of the goods employed were not quite perfect an addition of some bone-black (1:1000) to the raw grain would do good service.

It having been discovered that the composition of wort did not always come up to what might be expected in practical work, A. Schwarz, about a year afterward, proposed to withhold part of the malt and add it to the total mash after the raw cereal wort had been run in, proper temperatures being observed. The proposition met with approval and proved successful.

Mention may here be made of an improvement in this process, which was made by R. Wahl. A greater degree of stability had come to be required, of late, in beer, and a slight haze was often found in beers made according to this method, or bottle beer became turbid readily. Wahl attributed this precipitate to the albuminoids of the malt last added, which could not be properly converted at the high temperatures at which they entered the mash. It is, therefore, advisable for bottle beers to dough-in all the malt at low temperatures, or to run off the liquid part of the mash at a low temperature and add it once more at a higher degree of heat.

Distilleries had long been employing steam pressure for the purpose of dissolving the starch of their raw material, potatoes and corn, and it was natural to introduce the same process into raw cereal brewing. Thausing referred to experiments in this line in 1882, mentioning the Macerator and the Hollefreund apparatus. Some experiments were also made in the United States, but no results obtained until, in 1887, L. Frisch carried these experiments out practically and by pursuing the idea made an unquestioned success of it. He was followed by Rach, whose process differed from that of Frisch, in that he combined with the dissolution of the raw cereal starch under steam pressure, a mashing method for obtaining worts with a relatively low percentage of sugar and high percentage of dextrin.

The extract obtained by Frisch from corn was much higher than this material had been known to yield before. It was subsequently found that by boiling the corn a longer time than had been recommended prior to this period (see Siebel, 1881, and Weingaertner, 1887, both of whom mention 30 minutes as the maximum time of boiling) approximately the same yield could be obtained in the ordinary cooker.

PURE STARCH AS A MALT ADJUNCT.

Pure starch naturally was considered the most perfect raw adjunct for malt, and considerable quantities of wet or green starch were used in breweries, but with little success. Such attempts were frequently attended with deposits under the false bottom and consequent starch turbidity of wort and beer.

Recently, M. Henius succeeded in elaborating a method whereby the difficulties that prevented the use of pure starch in brewing are removed. Henius' method of treatment will be found in detail under "Treatment of Unmalted Cereals."

AMERICAN LAGER BEERS.

Materials.—In America pale malt is generally used for pale, as well as dark beers, for the latter an addition being made of caramel malt, black malt, roasted malt, roasted corn or sugar color. (See Brewing Materials.)

For pale beers, malt, together with unmalted cereals usually to the amount of one-third of the grist, but varying from 10 to 50 per cent, are used. The most popular material in an unmalted condition is prepared corn in the form of corn grits, or corn meal, while flakes are also largely employed, and have the advantage of direct addition to malt-mash, not necessitating any previous treatment whatsoever by the brewer. Corn flakes, rice and, lately, cornstarch share the favor of the brewer in the production of a high class bottle beer, and sugars, like anhydrous and glucose, may be used for kräusening purposes. Unmalted wheat is also employed locally.

As to the advantages of unmalted cereals, as compared with malt, it may be said that, aside from the point of view of economy, the character of the beer as produced by their aid meets with greater favor with the American public on account of lighter color, greater brilliancy and stability, and lighter body than all-malt beers.

As to the respective merits of the various unmalted cereals, cornstarch and other corn goods, like corn flakes, corn grits or meal can be used equally as well as rice, if the amount of corn oil does not exceed that of rice. Wheat has the advantage of a larger amount of desirable albuminoids, but the disadvantage of a

larger amount of undesirable albuminoids also. Consequently, beers produced with the aid of wheat, instead of corn or rice, will show increased palate-fulness, but a decreased stability of the bottled goods.

The amount of materials to be used per barrel of beer depends upon the gravity or strength of the wort, and the yield of the material. The brewery yield will never be so high as the laboratory yield, but should approach it within 2 to 3 per cent. A good quality of malt should yield 64 to 65 per cent of extract, a good quality of corn grits, corn meal, 75 per cent, corn flakes and rice 78 per cent.

Malt Beers are brewed from 12 to 15 per cent Bllg., and require from 50 to 65 pounds of malt.

Pale lager beer should be brewed from 12 to 13 per cent Bllg., and require from 48 to 53 pounds, of which one-third may be unmalted cereals.

Pale bottled lager beers should be brewed 13 to 15 per cent Bllg., and require from 52 to 60 pounds of material, two-thirds of which may be malt and one-third unmalted cereals.

Temperance beers are brewed about 7 to 8 per cent Bllg.

Malt tonics are brewed about 15 to 18 per cent Bllg.

For details of the manufacture of bottle beers, temperance beers and tonics, see "Special Beers."

Water.—The amount of water to be employed in the production of one hundred barrels of wort is approximately 135 barrels. Some of the water employed is left in the grains (about 20 barrels), some is evaporated in boiling (about 10 barrels), some is evaporated on the surface cooler (about 5 barrels).

In the production of all-malt beers, one-half of the water employed in making a brew should be reserved for sparging. Where unmalted cereals, like corn and rice, are employed, three-fifths of the water may be reserved for this purpose.

MALT LAGER BEERS.

Strength of wort, 12 to 15 per cent, Balling.

Materials, 50 to 65 pounds of pale malt per barrel for pale malt beers. If beer is to have dark color use, along with the pale malt, a mixture of caramel and black malt to the amount of 6 to 12 pounds per barrel.

Take one barrel of water to 100 to 125 pounds of malt for doughing-in; initial temperature 100° F. (30° R.). Hold this temperature 30 to 60 minutes, run up to 154° F. (54° R.) in 15 minutes with live steam and hot water, hold this temperature 15 minutes, run up to 163° F. (58° R.) in 15 minutes.

Live steam can be employed directly for heating the mash, if the water used for boiler feeding is of good or medium purity, i. e., if it does not impart to the steam any obnoxious substances. Care should also be taken in the selection of a proper boiler compound for the same reason.

Instead of heating with live steam the mash-tun may be provided with a steam jacket or coil.

Not more than one-half of the water to go into the mash should be used in doughing-in, leaving the other half for sparging.

Where live steam is not available and hot water must be used, the mash should ordinarily be started not lower than 133° F. (40° R.) in order to obtain a final temperature of 163° F. (58° R.) with enough water available for sparging.

Were the mash to be started below 133° F. (45° R.) too much water would be used for the mash liquor in raising the temperature of the mash, leaving correspondingly less for sparging.

An initial temperature in excess of 145° F. (50° R.) is not advisable in any case, as it interferes with the conversion of the albumen into peptones and amides.

Caramel and black malts are crushed and added to the malt mash when the temperature has reached 154° F. (54° R.).

PALE LAGER BEERS.

Strength of wort, 12 to 13 per cent, Balling.

Material, 50 to 55 pounds per barrel, of which about two-thirds should be pale malt and one-third may be unmalted cereals, like corn grits, corn meal, corn flakes, cornstarch or rice. Sugars like glucose may also be employed to the amount of about 25 per cent in place of unmalted cereals.

TREATMENT OF UNMALTED CEREALS.

The starch of raw cereals being more refractory than that of malt, requires longer boiling, together with malt or under high pressure. The common practice is to treat the raw goods in a separate vessel and run them in on the malt mash in the mash tub which has been previously started.

With *grits and meal* use: For 100 pounds of material in rice tub, one barrel of water; for 100 pounds of corn, 30 pounds of malt. Boil grits 75 minutes, meal 45 minutes.

With *rice* use: For 75 pounds of material in rice tub, one barrel of water; for 100 pounds of rice, 25 pounds of malt. Boil 30 minutes.

Start the malt mash as for a pure malt brew. Then start raw cereal mash in rice tank. Initial temperature, 100° F. (30° R.) in rice tank, hold this temperature 15 minutes, run up to 158° F. (56° R.) rapidly, hold this temperature 30 minutes, run rapidly to boiling point, boil for a time as indicated for the different materials, run mash into mash tub, so as to get a temperature of 154° F. (54° R.), when all is down. Hold this temperature in mash tub 15 minutes, raise to 163° F. (58° R.) with steam and hot water in 15 minutes.

After running down the raw cereal mash to the malt mash, a few barrels of water should always be forced in under the false bottom through the underlet, to clear the openings.

The more finely the goods are distributed and the longer they are cooked, the more completely will the starch be opened up. Corn or rice may yield 70 to 80 per cent of extract, malt, 64 to 68 per cent.

With *corn flakes* of good quality, that have been previously prepared in their manufacture so as to have the starch opened up, no cooking is necessary. Add these dry in mash tub, when temperature has reached 154° F (54° R.). Hold temperature 15 to 30 minutes (until saccharification) after addition, and run up to 163° F. (58° R.) in 15 minutes.

Corn starch should be treated in rice tank, as follows: For each 100 pounds of corn starch, use 30 pounds of malt. Dough-in with cold water, using one barrel for each 125 pounds of material; raise temperature to 160° F. (57° R.) in about 30 minutes, mash at this temperature for 30 minutes, go to 178° F. (65° R.) in 20 minutes, then rapidly to boiling, boil for five minutes and run down to malt mash.

Wheat and wheat malts are mashed together with the barley malt. Not more than 25 per cent should be employed, on account of the larger amount of undesirable proteids.

Sugars like glucose or grape-sugar are added in the kettle.

WAHL'S "LAUTER-MASH" METHOD.

In order to get worts richer in extract and with less alcohol than ordinary worts, use initial temperature of 100° F. (30° R.). Hold here 30 to 60 minutes, draw off the liquid portion—"lauter-mash"—reserve this at ordinary temperature, run the malt mash with the mash from the rice tank or with steam and hot water up to any point between 167° to 176° F. (60° to 64° R.), hold 15 minutes, and run in the "lauter-mash." The mash is now held at 167° F. (60° R.), and rapidly converted. The more alcohol and more extract is wanted, the higher is the temperature varied before addition of the "lauter-mash."

This "lauter-mash" may also be used in the rice tank instead of malt, especially to good effect when a high percentage of grits, meal or rice is employed in which case there is an insufficiency of malt husk in the mash tun. The rice tank mash may be conducted as follows:

Run water of ordinary temperature into rice tank, one barrel to 110 pounds of material, turn on steam, run in material, raising temperature to 158° F. (56° R.), run in lauter-mash, holding temperature at 158° F. (56° R.) for 30 minutes, go slowly in 30 minutes to 176° F. (64° R.), then rapidly to boiling point, boil and continue as usual.

ANTON SCHWARZ'S AFTER-MASH METHOD.

Another method aiming to increase the percentage of unfermentable extract of the wort, is to reserve about one-third of the malt and add it to the mash after it has reached about 54° R., without necessitating the addition of any more water. This method can be recommended for unsteamed beers. It not only increases the percentage of unfermentable extract, but permits of the employment of more sparging water.

BONE-BLACK.

This is used in the mash at times to cure a mouldy odor of the goods.

If brewing materials—malt, corn, grits—have a mouldy or other off-smell, five pounds of bone-black, of the quality used in sugar refineries, run into the mash with the malt for every 1,000 pounds of material, will give a good result.

For raw cereal beers, add the bone-black while the raw cereal mash is running down into the malt mash.

RAW CEREAL MASH UNDER PRESSURE.

An increased yield will be obtained from raw cereals if they are cooked under pressure. There are two apparatus for this operation, in common use, the Hollefreund and the Henze.

The "Hollefreund" is an horizontal cooker, and was first operated according to Frisch's method, as follows:

Cold water is run into the cooker, then the corn goods. The temperature is raised to boiling point, the air is allowed to escape, the cooker is closed, the pressure is raised to 60 pounds 300° F. (120° R.). Hold here 15 minutes. Now blow off carefully, until 212° F. (80° R.) is reached, then connect with vacuum pump and reduce temperature to 158° F. (56° R.). Run in 15 per cent of malt, and after inversion, run up to 192° F. (71° R.) and run the raw cereal mash into mash tub.

The "Henze" apparatus is an upright cooker, and was first operated by Rach's method, as follows:

Water, corn and malt are run in, temperature is raised to boiling point, air is allowed to escape, then the cooker is closed, pressure raised to 30 pounds and the raw cereal mash forced into the mash tub. The temperature of the entire mash is usually raised to 181° F. (66° R.), then a "diastase solution," which was drawn at a lower temperature, is added, together with some cold water, to reduce the temperature to 172° F. (62° R.), where inversion takes place. Either method, however, can be modified according to circumstances.

Rach's method is based upon the principle of brewing beers with a low percentage of alcohol and high percentage of unfermentable extract. Both horizontal and vertical cookers can be used in connection with or without vacuum pump, and the same method of operation can be carried out in either. It is not advisable to raise the pressure higher than 30 pounds, as this is quite sufficient, unless darker worts are desirable. In conducting the malt mash and in running the cooker mash into the mash-tun, the temperatures in the mash-tun may be taken as given under "Pale Lager Beers" if a low percentage of alcohol in the beer is not desired.

Yield with pressure cooker—
- From malt ....64 per cent to 70 per cent
- From corn or rice..............75 per cent to 80 per cent

Yield without pressure cooker—
- From malt ....64 per cent to 68 per cent
- From corn or rice............70 per cent to 75 per cent

PALE EXPORT LAGER BEERS. (BOTTLED OR DRAUGHT.)

Export beers should be of a high grade. The amount of alcohol should be somewhat higher than in pale beers for the city trade on account of the greater requirements as to stability that the beers must meet, especially when not steamed.

Strength of wort, 13 to 15 per cent Balling.

Materials, 52 to 60 pounds per barrel, of which two-thirds may be malt and one-third fine quality of corn, rice, corn flakes, or cornstarch. Use low initial temperature, peptonize well by holding one hour and mash as usual. Details of export bottled and draught beer production, see under "Special American Beers," where will also be found temperance beers, tonics, common beer, steam beer, and others.

EXTRA PALE LAGER BEERS (BOTTLED OR DRAUGHT).

Strength of wort, 13 to 15 per cent Balling.

Materials, 50 to 56 pounds per barrel.

Use 50 per cent low dried malt, 30 per cent grits, rice or cornstarch, and 20 per cent anhydrous grape sugar or glucose;

Or use 50 per cent low dried malt, 30 per cent grits, rice, or cornstarch, and 20 per cent corn flakes.

The brewing water should be of medium hardness. If quite soft, darker color of wort and beer will result. If the water is too soft, it should be hardened by adding proper amounts of sulphate of lime. Alkali waters should be treated by adding chloride of calcium or plaster of Paris.

Start mash at 122° F. (40° R.) instead of 100° F. (30° R.), hold for about 15 minutes, and then proceed as usual.

THE MASH AT REST.

When the end temperature is reached, a sample of the mash should not show any starch by the iodine test. If it does, we should continue to run the machine until all starch has disappeared, or, if we have reason to assume that this would require too long a time, we should cool the mash to 158° F. (56° R.) with water—in case of malt poor in diastase—and add some more crushed malt. The last few degrees should be obtained by running hot water through the underlet or "pfaff."

The stirrer is now stopped, or, in the mashing machines of modern construction, lifted out of the mash. Shortly after the stirring has stopped, the surface of the mash should appear grained or mottled. The taps are now opened, one after the other, the wort is allowed to rush out for a few seconds, and the taps are again closed. This is done to remove underdough. Let the malt mash rest 30 minutes and the raw cereal mash 45 minutes. If allowed to remain standing too long the grains will settle too firmly.

RUNNING OFF THE WORT.

Open the taps wide, one by one, for a few seconds, and close them again; the recoil of the liquor will rinse out more underdough. Then open the taps gradually until a proper flow of wort is obtained. Pump the wort back into the mash tub as long as it runs turbid, which usually lasts 8-15 minutes. As soon as the surface of the grains has run dry, remove the upperdough, or stir it up with crutch or machine to prevent channels being formed in the goods, which would prevent the sparging liquor percolating uniformly through the grains.

The wort should flow quite bright. If it remains hazy after all suspended matter has disappeared, there are undesirable albuminoids present, caused either by imperfect malt or faulty mashing.

SPARGING.

This process consists in sprinkling hot water over the grains to wash out as much as possible of the valuable constituents remaining in them. The amount of sparging water should be considered when starting the mash, with reference to the total amount of wort desired.

When so much wort has been drawn off that the grains are barely covered by the liquid, sparging should begin. Sparge four to five times, using for each 100 barrels of sparging water:

For first sparging	30 bbls.
For second sparging	25 bbls.
For third sparging	20 bbls.
For fourth sparging	15 bbls.
For fifth sparging	10 bbls.

Or, the sparging water can be sprinkled on continually as fast as the wort runs off, keeping the grains covered about one inch with water. The temperature of the sparging water should be 167-172° F. (60-62° R.). Higher temperature may lead to starchy turbidity, lower temperature to souring. The spargings should be tested from time to time for starch. The first wort may be absolutely free from starch while the spargings may show considerable amounts of starch, generally due to the employment of high sparging heats. If the first wort runs off too slowly, let it run off entirely, then start machine, mixing the grains thoroughly while the first sparging water is forced in through the underlet.

The first wort should have a gravity of 18 to 20 per cent Balling, varying with the amount of water used for malt and cereal mashes.

Enough sparging water having been added and the wort having run off almost entirely, the last run will be turbid, but should have no greater density than 1 per cent by the saccharometer.

The loss due to incomplete washing out of the grains is approximately equal in per cent to the percentage that the water pressed from the grains shows. In order to compute the loss from this source, take a sample of grains from the grains-box, press it, and find the amount of extract in the water by means of a saccharometer. If this were found to be 1 per cent, then the amount of loss would be 1 per cent of the weight of the material employed, since the amount of water in the grains is approximately equal to the weight of the grist. If, f. i., 8,000 pounds of malt and 4,000 pounds of corn were used for a brewing, and the weight of the water pressed from the grains was 2 per cent, then the loss would be 12,000 × 2 per cent = 240 pounds, or about seven barrels of wort of 13 per cent.

SLOW FLOW OF WORT.

If the wort flows too slowly it is generally an indication that the goods have not been completely opened up, but it may also be due to one or more of the following causes:

1.—EXCESS OF UNDERDOUGH.

By underdough we mean those substances which gather between the false bottom and the real bottom of the mash-tun. Were this space to fill up completely, the wort and spargings could not run off at all. Where this space is filled up partly, the grains lying above the clogged section will not drain properly.

The underdough is mainly composed of starch.

The following conditions promote the formation of underdough:

a.—Crushing the malt too finely. The malt should not be ground fine, but each kernel should be simply crushed. The less malt flour finds its way readily through openings of the false bottom, the better.

b.—Running mash machine too long, especially at low temperature. The longer the mash machine is run, f. i., at 100-122° F. (30-40° R.), at which temperature the starch remains practically unchanged, the more of this starch will work its way under the false bottom. If the mash is to be held at a low temperature for some time, the machine should be stopped.

c.—If little or no water is run under the underlet while the mash machine is in operation, more solid particles will find their way under the false bottom, the upward current of water checking, in part, the downward motion due to gravitation.

d.—If the holes in the false bottom are large, underdough will be formed more readily.

e.—If the space is high below the false bottom, underdough will form more readily. (See also Brewing Outfit.)

2.—EXCESS OF UPPERDOUGH.

By upperdough we mean the layer of finely divided light particles uppermost in the grains. This layer is, in the main, composed of particles of cellulose and albumen, and the more of it forms,

a.—The finer the malt is crushed,

b.—If the mash machine is run too long, resulting in more particles being scraped off the husks, etc.

c.—If a large proportion of unmalted cereals is used.

This upperdough should always be removed by chopping and mixing it into the body of the grains before sparging.

3.—GRAINS SETTLING TOO COMPACTLY.

This may be due to:

a.—Letting the mash rest too long before tapping; 30 to 45 minutes should be sufficient.

b.—Draining the first wort, or spargings, too rapidly, in which case the liquor not being able to percolate through the grains as fast as it runs from under the false bottom, has the effect of compressing the grains, in proportion to the height of the liquid column.

c.—Running too much sparging water on the grains, this water acting as so much weight,

d.—If malt is flinty,

e.—If the mash-tun is too high in comparison to diameter; the mash in the tun should be about 36 inches high, the grains after draining about 18 inches.

4.—SCARCITY OF FILTERING MATERIAL.

a.—When using large amount of unmalted cereals,

b.—When using malt with thin husk,

c.—When using much malt in rice kettle.

d.—If the diameter of the mash-tun is too large compared with its height, in which case the layer of filtering material (grains) will be too low.

5.—GRAINS STOPPED UP.

If the body of the grains becomes stopped up by unconverted starch in a semi-paste form, or by undesirable proteids.

BOILING THE WORT.

PRINCIPLES OF BOILING.

The wort obtained by mashing is boiled for a certain period for the purpose of eliminating or rendering harmless certain undesirable constituents, and introducing other new bodies by extraction from the hops. These changes taking place during heating and boiling are the following:

1.—*Destruction of the diastase above* 178° F. (65° R.),

2.—*Precipitation of the proteids,* which is the more complete;

a.—If mash is well peptonized, that is, if the mash was held sufficiently long at lower temperature, in which case there is a larger amount of precipitation, and this precipitation is more flocculent than when employing high initial mashing temperatures.

b.—If the wort is boiled the proper length of time. The proteids are not precipitated at once when boiling temperature is reached. They continue to be precipitated on extended boiling. It seems, however, that certain forms of albuminoids, probably the albumoses, are changed to proteids of a type that is not readily precipitated on boiling, but remains in the wort and gives rise to proteid turbidity in the wort or beer on cooling. At any rate, it has been observed that prolonged boiling results in bottled beers of decreased stability when steamed.

c.—If boiling temperature is below 212°, less proteid matter will be precipitated than at 212° boiling point. On this account it is difficult to brew beers of good keeping quality in breweries located at high altitudes (in the Rocky Mountains, f. i.). The copper kettles in such breweries should be so constructed as to admit of boiling under a pressure of about five to ten pounds.

d.—If the wort is aërated during boiling the proteids seem to be precipitated more effectually. The door of the copper should, therefore, be kept open during boiling.

e.—The tannic acid of the hops aids in precipitating proteids; the more hops employed, the more proteids are eliminated.

f.—If the hops are added after most of the proteids are precipitated, that is, after about an hour's boiling, an additional quantity of proteids will be precipitated. The hops should not, therefore, be added too soon.

3.—*Evaporation of water.*

4.—*Deepening of the color* by concentration of the wort and formation of caramel, by means of the heat acting on the sugars.

5.—*Extraction of hop oil and hop resin.*

6.—*Destruction of bacteria.*

BOILING OPERATIONS.

In the United States the wort is always heated by steam, open fire kettles having gone quite out of use. Steam is turned on when the wort flowing from the mash tub covers the heating surface in the copper, and the temperature kept at about 190° F. (70° R.) until all the wort, including spargings, has run in. Unless very pale beer is desired, the brewer may bring the wort to a boil while it is flowing in. During the boiling period the wort should be kept in a state of vigorous ebullition.

An addition of hops of about 10 pounds per 100 barrels is given as soon as the wort comes to a boil, which has the effect of decreasing the danger of wort boiling over.

"BREAK" OF WORT.

While the wort is heated the undesirable albuminoids are partly precipitated and unite into lumps. The fluid between these floating lumps should, in time, become clear and transparent. This is the "breaking" of the wort, and it should be well "broken" before any hops are added.

BOTTLE BEER AND EXTRA PALE.

For bottle beer and extra pale beer, hold the temperature of the wort at 190° F. (70° R.) until the kettle is full. Boil for one hour, at the expiration of which time the wort should show a good first break. Then add ⅖ of the hops (fair quality), boil

40 minutes, when the wort should show a good second break. Add ⅖ of hops of a better quality, boil 20 minutes. Add ⅕ hops of the finest quality, and run out immediately. If the first or second break does not set in within the given time, do not use the beer for bottling.

For ordinary beers, boil until the wort is broken, and add first ⅖ of hops; otherwise proceed the same as for bottle beer.

HOPPING THE WORT.

The active agents extracted from the hops by boiling are the "resins," "oil," and "tannin."

The hop-resins impart the bitter taste, tend to preserve the beer, and protect the yeast.

The hop-oil gives the aroma of hops.

The tannin contributes to the precipitation of the albuminoids from the boiling wort.

An extension of the boiling period means the extraction of more hop-resin and tannin and the volatilization of more essential oils, causing a loss of aroma. The door of the copper is kept open while the wort is boiling, in order to admit air, which promotes the elimination of albuminoids.

The hops are added in portions, in order to secure both the desired bitter and aroma. The allowance of hops should be increased with a greater concentration of the wort. The inferior quality of hops should be added in the first portion.

The quantity of hops that ought to be used per 100 barrels of wort of 13 per cent B. is about 100 pounds; for lighter beers, less; for stronger ones, and for bottled beers, more.

HOP PREPARATIONS.

There are certain preparations made from hops which may be used to good advantage instead of the whole cone. Such preparations are hop extract and lupulin.

A hop extract is produced by extraction in naphtha, which is the dissolving agent usually employed. This naphtha is afterward driven off by evaporation.

Lupulin from good hops, and unadulterated, is quite unobjectionable, but care should here be taken, as the high price of the product is a temptation to adulterate it, and it occurs in the market mixed with sand, tannin, brickdust, etc., or it is taken from old hops.

Only 25 per cent of the hops should be replaced by these products, employing one pound of hop extract for 12 pounds

of hops of the first portion of two-fifths, or one pound of lupulin for 12 pounds of the second portion of two-fifths, or the third portion of one-fifth. The can containing the hop extract is punctured, tied to a chain and hung into the boiling wort near the bottom. Under these circumstances the extract will be dissolved more readily.

AIDS FOR ELIMINATING ALBUMINOIDS.

"Irish moss" is often added in the kettle. It should be washed with cold water and 2.5 pounds taken for 100 barrels of wort, adding the same ten minutes before running out. Long boiling weakens the effect of the moss.

The effect of the moss is due to a glue-like substance, which acts in a similar manner to isinglass. It operates after the wort has cooled, by coagulating, and enveloping the floating albuminoids, causing them to ball up more readily and seek elimination, either by rising to the surface or settling.

Fifty pounds of "common table salt" added for 100 barrels of wort is recommended where the brewing water contains no salt. It not only aids the "breaking" of the wort, but also improves the taste of the beer. It should be added about half an hour before running off the wort from the copper.

COOLING.

From the copper, the wort runs into the hop jack, where it is allowed to stand for a period, to permit the hops and albuminoids to settle.

The wort should not be allowed to rest longer than 15 minutes, as a dark color or rank, bitter taste may result if wort is left in contact with hops too long. Where the wort cannot be taken care of by the coolers within a reasonable time, it would be advisable to provide a suitable storage tank for the hot wort, or to place the false bottom of the hop-jack higher up, or else provide the kettle with a hop strainer.

The hops should be sparged with about five barrels of hot water per 100 pounds of hops. As the hops form but a thin layer in the hop-jack, they could be profitably taken out, placed in a separate strainer with smaller diameter—a hop press with a metal shell instead of basket would answer—where sparging would be more effective. (See Brewery Outfit.)

The hops should not be pressed, as is often done, as substances are thereby embodied in the wort that tend to impart a rank, bitter after-taste to the beer.

THE WORT ON THE SURFACE COOLER.

The wort is next run or pumped to the surface cooler for the purpose of preliminary cooling.

The wort should be cooled to 145° F. (50° R.), and not lower, on the surface cooler, and receive proper aëration during cooling, avoiding all sources of contamination in the meantime. Aëration of the wort during cooling has the effect of further precipitating undesirable albuminoids. Besides, the wort absorbs air, which is utilized by the yeast later on. Most of the microbes that reach the wort below 145° F. (50° R.) will remain alive, the most common ones being butyric and lactic acid ferments and wild yeasts.

The wort cools the more rapidly:

1. The lower the temperature of the air;
2. The better the aëration; Theurer's apparatus dispenses with the surface cooler altogether. The wort is pumped into a vat and thence runs straight over the Baudelot cooler, which is supplied with filtered air. Aëration is complete, and the danger of infection minimized;
3. The more the wort is agitated, for which purpose stirrers may be employed;
4. The larger the surface of the wort compared with its depth;
5. When atomized; for this purpose the wort may be sprayed on to the surface cooler, the wort thus coming in contact with a large quantity of air, which increases aëration and accelerates cooling. The danger of infection, however, must not be ignored. If a spraying system of cooling and aërating be adopted, the air that has access to the surface cooler should be filtered;
6. When the sky is clear, more rapidly than when cloudy;
7. When the surface cooler is constructed of metal, more rapidly than when made of wood.

If the wort looks foxy on the surface cooler, it contains in suspension bodies that will not settle readily.

After the preliminary cooling the wort is sent over the Baudelot cooler, where it should be cooled down to 48° F. (7° R.), which is sufficiently low. Formerly it was a general rule, however, to cool the wort to as low a temperature as 42° F. (4.5° R.). At this temperature in the settling tank it should show a good, cold "break," and a sample should filter clear at the temperature of the fermenting cellar. If it does not, the causes may be as follows:

CAUSES OF UNSATISFACTORY "BREAK" OF WORT.

1. Starchy turbidity from incomplete inversion of the starch.
2. Proteid turbidity from incomplete inversion of the albuminoids or incomplete precipitation of the proteids.
3. Bacteria or yeast turbidity from infection.

A good cold break is an indication of a perfect wort.

LOSS IN VOLUME IN PRELIMINARY COOLING OF WORT.

A certain loss in volume will occur on the passage of the wort from kettle to settling tank, due to the following elements:

1.	Contraction in cooling...............	4.5 p. c.
2.	Evaporation of water.................	4.5—5.0 p. c.
3.	Adhesion of liquid to surfaces of kettle, hop-jack, cooler, etc...........	½ p. c.
4.	Wort adhering to hops in hop-jack when not pressed or sparged two barrels and one-half per 100 pounds of hops or approximately.............	2.5 p. c.
	Total loss when hops are not sparged or pressed, approximately..........	12½ p. c.
5.	By sparging with five barrels of water per 100 pounds of hops, the total loss will be reduced to about...........	7½ p. c.

Thus, 92½ barrels will reach the settling tank out of every 100 barrels leaving the kettle, if five barrels of water are employed for sparging 100 pounds of hops. By contraction in cooling and by evaporation no valuable substances are lost, excepting hop-oil.

(For German lager beers, ale, stout, weiss beer, common beer, see end of this chapter.)

INFLUENCE OF DIFFERENT MATERIALS AND MASHING METHODS ON THE COMPOSITION OF WORT.

The table on the next two pages shows the influence of different materials and mashing methods on the composition of wort which in a great measure determine the character of the beer. It is very interesting to note that from the same malt, worts were

INFLUENCE OF DIFFERENT MATERIALS AND MASHING METHODS ON THE COMPOSITION OF WORT. BY M. HENIUS. THE BREWS WERE MADE IN THE EXPERIMENT BREWERY OF THE AMERICAN BREWING ACADEMY OF CHICAGO.

No.	Material.	Temperature of Water, F.	R.	Mashing Method.
1.	All malt.	178°	65°	Mashed between 165°-169° F. 20 minutes. (59°-61° R.)
2.	All malt.	145°	50°	Mashed at 140° F. (48° R.) 2 hours. In one-half hour to 158° F. (56° R.)
3.	All malt.	106°	33°	Mashed at 100° F. (30° R.) 15 minutes. Rest mash at 100° F. (30° R.) 1 hour. With steam to 122° F. (40° R.) in 10 minutes. With steam to 153° F. (54° R.) in 20 minutes. Mash at 153° F. (54° R.) 10 minutes. With water to 165° F° (59° R.) in 10 minutes.
4.	65% malt. 35% grits.	106°	33°	Mashed at 100° F. (30° R.) 15 minutes. Rest mash at 100° F. (30° R.) 1 hour. With grits mash to 153° F. (54° R.) in 20 minutes. Mash at 153° F. (54° R.) 10 minutes. With steam to 165° F. (59° R.) in 20 minutes.
5.	65% malt. 35% grits.	106°	33°	Mashed at 100° F. (30° R.) 15 minutes. Rest mash at 100° F. (30° R.) 1 hour. Draw Lauter-mash. With steam to 140° F. (48° R.) in 20 minutes. With grits mash to 176° F. (64° R.) in 6 minutes. Add Lauter-mash, reducing temp. to 165° F. (59° R)
6.	60% malt. 40% rice.	127°	42°	Mashed at 122° F. (40° R.) 10 minutes. Rest mash at 122° F. (40° R.) ½ hour. With rice mash to 156° F. (55° R.) in 8 minutes. Mash at 156° F. (55° R.) 15 minutes. With steam to 165° F. (59° R.) in 15 minutes.
7.	65% malt. 35% flakes.	127°	42°	Mashed at 122° F. (40° R.) 10 minutes. Rest mash at 122° F. (40° R.) 30 minutes. With steam to 158° F. (56° R.) in 15 minutes. Add flakes at 158° F. (56° R.) in 15 minutes. Mash at 158° F. (56° R.) 15 minutes. With steam to 165° F. (59° R.) in 10 minutes.
8.	75% malt. 25% wheat malt.	115°	37°	Mashed at 111° F. (35° R.) 15 minutes. Rest mash at 111° F. (35° R.) 45 minutes. With steam to 149° F. (52° R.) in 10 minutes. Mash at 149° F. (52° R.) 10 minutes. With steam to 165° F. (59° R.) in 20 minutes.

INFLUENCE OF DIFFERENT MATERIALS AND MASHING METHODS ON THE COMPOSITION OF WORT. BY M. HENIUS. THE BREWS WERE MADE IN THE EXPERIMENT BREWERY OF THE AMERICAN BREWING ACADEMY OF CHICAGO.—(Continued.)

Yield lb. Extract in 100 lb. Material.	Original Gravity Per cent Balling.	Reducing Sugars. (Rohmaltose.)	Per cent Sugar (reducing) in Extract	Ratio of Sugar to Non-Sugar.	Albuminoids in 100 parts wort.	Per Cent Albuminoids in Extract.	Remarks.
56	11.8	6	51	100:97	0.6	5 1	Wort runs turbid, poor break in kettle and after cooling.
61	12.7	10.3	81	100:23	0.8	6.3	Wort runs fair; fair break in kettle and after cooling.
63	13.2	9.5	72	100:40	0.95	7.2	Wort runs clear, good break in kettle and after cooling.
67	12.5	9.6	77	100:30	0.56	4.4	Wort runs clear; good break in kettle and after cooling.
67.3	12.6	7.4	59	100:70	0.53	4.2	Wort runs clear. Good break in kettle and after cooling.
67.8	13.5	9.3	69	100:45	0.52	3.9	Wort runs clear; good break in kettle and after cooling.
67.3	14.1	9.4	66.7	100:50	0.67	4.3	Wort runs clear; good break in kettle and after cooling.
66.4	13.1	9.5	73	100:38	0.9	6.9	Wort runs clear; good break in kettle; fair after cooling.

obtained in which the amount of sugar varied from 51 to 81 per cent of the weight of the extract, while the albuminoids varied from 5.1 to 7.2 per cent. High initial temperatures yielded worts with a low percentage of sugar and low percentage of albuminoids. The malt mash held at 30° R. one hour was shown to give the best results regarding amount of albuminoids. Whenever unmalted cereals were employed the amount of albuminoids was reduced proportionally with their amount. Wheat malt yielded an equal amount of albuminoids as barley malt. The worts from the high initial temperature mash No. 1 and from No. 2 where the machine was run abnormally long, ran turbid or fair from the grains and did not break well in the kettle and after cooling, and the beer from No. 1 did not clarify. The wheat malt wort acted in the same way, only it ran clearer from the grains. All other worts ran brilliant from the grains, broke well in the kettle and after cooling, and the beers clarified properly.

Mashes 1 and 2 were made with a view to determine the extremes of dextrin and sugar percentages in the extract of the wort, and have no practical significance. Mashes 4 and 5, which were produced with the same properties and qualities of malt and grits, show that the percentages of sugar can be materially lowered by raising the temperature more rapidly from the initial to the final temperature, especially when Wahl's Lauter-mash is employed, as is the case in Mash 5. Mash 7 shows the reduction of sugar and a corresponding increase of dextrin by the addition of corn-flakes at a higher temperature as compared with Mash. 4.

FERMENTING CELLAR OPERATIONS.

METHODS OF FERMENTATION.

With reference to the character of the beer to be produced, as far as it is determined by the process of fermentation, three methods of conducting fermentation are distinguished:

1. Top fermentation, for ale, stout, porter, weissbeer.
2. Bottom fermentation, for lager beer and American steam beer.
3. Spontaneous fermentation, for Belgian beers (Lambic, Faro).

Bottom fermentation proceeds at low temperature, viz., 42-51° F. (4.5-8.5° R.); top fermentation at higher stages, as 57-73° F. (11-18° R.). In bottom fermentation, the temperature during the process rises 7 to 11 degrees F. (3-5° R.); in top fermentation, 11-16 degrees F. (5-7° R.).

The designations of the two types of fermentation are derived from the fact that in bottom fermentation the yeast for the most part settles on the bottom, whereas, in top fermentation, it rises to the surface.

Bottom fermentation takes 8-16 days; top fermentation but a few days.

STAGES OF FERMENTATION.

Fermentation in the brewery proceeds in two distinct stages:

1. "Principal," "primary," or "main fermentation," consisting in the splitting of maltose at relatively higher temperature, for bottom fermentation, 42° to 51° F. (4.5° to 8.5° R.); for top fermentation, 57° to 73° F. (11° to 18° R.).
2. "Secondary," or "after-fermentation," consisting in the splitting of the malto-dextrin at lower temperatures, in bottom fermentation by culture yeast at 34-37° F. (1-2° R.); in top fermentation by culture or wild yeast about 55° F. (10° R.).

AVERAGE PROGRESS OF PRINCIPAL FERMENTATION.

System of Fermentation.	Yeast.	Temperature.	Period.	Result.
Bottom fermentation ..	Bottom	42—51° F 4.5—8.5° R.	8—16 days.	few foreign ferments, little lactic acid.
Top fermentation	Top.	57—73° F. 11—18° R.	3—5 days.	more foreign ferments, more lactic acid.
Spontaneous fermentation.	Wild yeast and bacteria.	57—66° F. 11—15° R.	30—40 days.	many foreign ferments, much lactic acid.

BOTTOM FERMENTATION.

PITCHING WITH YEAST.

Fermentation is induced in the wort by adding yeast, which operation is called "pitching."

The wort runs from the pipe cooler into a collecting vat or straight into the fermenter, where fermentation is started. During pitching the wort should be well roused repeatedly, so as to secure a uniform distribution of the yeast and an intimate mixture of yeast and wort. There are different ways of pitching.

REFRESHING AND DEVELOPING THE YEAST.

Before the yeast is added to the bulk of the wort it is mixed with about an equal quantity of either finished wort or boiled first wort of 55-68° F. (10-15° R.), well aërated, and added either at once or after the yeast has developed, that is, after the mixture has come into Kräusen. The mixing and aërating may be done in special appliances, stirring the wort and yeast vigorously while at the same time air, preferably filtered air, may be blown into the mixture. Where the amount of yeast to be handled is not very large it may be effectively roused and aërated by pouring the mixture of wort and yeast repeatedly from one bucket into another, letting it fall through the air as high as a man can lift it.

When the refreshed yeast is allowed to come into Kräusen, and is then added to a large quantity of wort, the sudden drop in temperature may check the growth of the yeast, which has by this time become vigorous. It is therefore a better plan to let the wort as it cools run into the refreshed and developed yeast, which may for this purpose be placed into the settling tank or pan of the Baudelot cooler.

While running the wort into the settling tank which contains

the yeast, the wort should be roused either with crutches or it may be roused and aërated at the same time by blowing in filtered air.

DOUBLING.

The wort is pitched as usual with the refreshed and developed yeast. When the beer in the vat has come into Kräusen it is divided into two parts, and each vat is filled up again with wort; when this is in Kräusen, it may be again divided, and the vats filled up. Then the fermentation is allowed to proceed as usual, but the operation may be repeated a number of times more with good results. This method may be well employed when the yeast is changed and it is desired quickly to propagate a new crop of yeast from a small quantity introduced; 50 to 60 pounds of yeast will give a new crop of 150 to 200 pounds of new yeast from every 50-barrel vat.

AMOUNT OF YEAST FOR PITCHING.

The amount of yeast per barrel required to secure a normal fermentation is governed by the density of the wort, the pitching temperature, the condition and properties of the yeast, and the treatment of the same. The stronger the yeast, the weaker the beer is brewed in, the better the aëration and the higher the pitching temperature (within reasonable limits), the smaller will be the quantity of yeast necessary for pitching; ordinarily 1¼ pounds per barrel will be found sufficient where the original gravity of the wort is 13 per cent B., the pitching temperature 42° F. (4.5° R.), and the yeast thick and strong. If boiling fermentation sets in, more should be used.

Where the yeast is added dry without refreshing and developing, more yeast is required. The smallest amount is needed where the wort is run in on the refreshed yeast.

FERMENTATION PHENOMENA.

Within 15-24 hours, according to the pitching temperature, little white bubbles appear around the sides of the vessel. The wort at this time is covered with a head of a thick, lumpy consistency, composed largely of albuminoid matter, coagulated during the boiling period. Upon blowing aside this head, a fine white froth will be observed underneath, indicating that fermentation is setting in. The head of impurities being skimmed off, the whole surface is found to become quickly covered with a fine white froth ("whitening over"), rather higher around the rim than in the middle. This shows that fermentation has become active, and takes place 18-30 hours after pitching.

KRAEUSEN.

The head of froth begins to move from the sides of the vessel to the middle, and assumes a frizzled appearance, small cockle-shaped mounds beginning to rise all over the surface. This is the stage of "Kräusen," answering to what the English brewer call the "cauliflower" stage. At the expiration of 20 to 40 hours after pitching, the surface should be curly and pure white. ("Young Kräusen"). From the time the froth head begins to move toward the middle, fermentation becomes more active, the head rising higher all the time ("High Kräusen"). At the same time the temperature rises, slowly at first, more rapidly as the activity of fermentation increases, while the saccharometer falls with increasing rapidity, the drop amounting to one-fourth to one-half of one per cent. a day in the early part, and reaching one to one and one-half toward the high Kräusen stage. The curly head of froth turns a darker color while rising in height. The dark secretions commonly collect at one point and form a cap.

The high Kräusen stage is reached 70 to 80 hours after pitching and is maintained for a period of 48-72 hours, varying according to different influences. During this time the beer is kept at a certain low temperature, 48° to 50° F. (7° to 9° R.), by means of attemperators, and when the head begins to collapse is cooled slowly to 39° F. (3° R.). The saccharometer falls more slowly as the end of the principal fermentation draws near. When the end is reached, the fall of the saccharometer should be $\frac{1}{10}$ to $\frac{1}{20}$ per cent in 24 hours.

COLOR AND "BREAK."

The color of the beer begins to deepen from the time of the Kräusen collapsing, and from a foxy appearance it gradually passes into a deep black, about 8 to 16 days after pitching. At that period, if a sample is taken in a sample glass, the yeast particles suspended in it should be visible to the naked eye. The yeast should bunch together, the beer should "break" well. In a sample glass the impurities should settle in 2 to 3 hours in a warm room, and in 24 hours in the fermenting room, leaving the beer perfectly clear. These conditions existing, the principal fermentation is completed.

THE YEAST CROP.

When the beer is ripe for tanking (racking on Ruh), the beer should be drawn or pumped from the fermenting vat, avoiding all agitation, as the yeast has a tendency to rise by the escape of carbonic acid gas under the yeast.

The quantity and soundness of the yeast crop are largely influenced by operations during the progress of fermentation. In the beginning the matter in suspension in the wort, composed mainly of proteids, will partly settle and partly gather at the surface in the fermenting tub. In order to obtain the yeast as free as possible from this suspended matter, hop-resin and other substances like hop-resin that appear in the Kräusen:

1. Skim off the dark head after the appearance of Kräusen, or run the beer into another vat as soon as in Kräusen.
2. Remove the dark particles of hop-resin from the Kräusen while the latter are falling back.
3. Skim off the cover before racking on storage ("Ruh").

The bulk of the yeast will be found settled on the bottom. The top, which is darker from admixtures of hop-resin, is apt to contain more light yeast, and small cell types, like wild yeast, if present in the beer at all, are found in greater quantities in the top layer. This dark layer should be skimmed off. The middle layer will be found to be lightest in color, and this part only should be preserved for future fermentations, leaving the bottom stratum, which again has a deeper color, and, having been first deposited, contains larger quantities of old, dead, and weak yeast cells, to go among the refuse.

The middle layer which is conveyed to a yeast tub, may be at once refreshed and developed for pitching or left standing without watering for a few days if properly kept cool by "swimmers," or attemperator pipes, not by ice directly, since ice may contain impurities. The yeast may also be watered, which is preferably done the day before using. Next morning the surface water with the yeast particles floating on it is drained off, and the yeast refreshed and developed as for a new fermentation.

The new yeast crop should be most carefully examined before being used again, and if found in any way unsound or contaminated, should be treated as directed under the respective heads.

FERMENTATION PHENOMENA EXPLAINED.

The fermentation phenomena may be explained as follows: As soon as the yeast is stirred into the wort it begins to split up the sugar into alcohol and carbonic acid, thereby developing heat, in consequence of which the temperature of the fermenting liquid rises, and the indication of the saccharometer becomes lower as the sugar is decomposed. The carbonic acid escapes, with the exception of about ⅕ per cent, which remains in the beer, part of the escaping gas raising the head of Kräusen. This escaping gas carries to the surface all the flocculent particles in suspension, like the coagulated albuminoids, giving rise, in the first stages of fermentation, to the thick, dark cover of scum. The hop-resin, which is held in solution chiefly by the sugar, becomes less soluble as the sugar decreases, and is carried, together with coagulated albumen, to the surface of the beer, where it discolors the Kräusen, or settles on the bottom, discoloring the yeast. The yeast multiplies during fermentation, is kept suspended by the escaping carbonic acid gas, and thus gives the beer a somewhat reddish appearance. The activity of the yeast increases up to the high Kräusen period, then gradually settles, and as fermentation draws to a close the beer appears darker in the vat. When the head collapses, there is comparatively little sugar left in the wort. Hence, the saccharometer falls with increasing rapidity up to the collapse of the head, and the temperature rises, whereas, after that time, the saccharometer falls more slowly, and the temperature decreases, owing to the atmosphere of the fermenting room being about 41° F. (4° R.) and cooling the liquid more rapidly than the diminishing activity of the yeast serves to heat it, even without the use of attemperators.

The higher the temperature, and the larger the quantity of yeast in the beer, the quicker will the sugar ferment, the quicker will the temperature rise, the quicker will the saccharometer fall, the quicker carbonic acid will develop, the higher will the Kräusen rise.

The fall of the saccharometer indication, according to Balling, is called "apparent attenuation," and the percentage of this fall, the "apparent degree of attenuation." The indication of the saccharometer itself at the end of the fermentation period is called the "apparent extract of beer." Taken together with

the original gravity of the wort, the apparent attenuation enables the calculation of the percentage of alcohol, from which, in turn, is determined the real attenuation, the "real degree of attenuation," and the Balling of beer. (See "Figuring in the Brewery.")

The consistency of the Kräusen head is due largely to the viscousness of the albuminoids by which the high volütes of foam are held together, to collapse after the generation of carbonic acid has fallen below the amount necessary to support the foam.

The yeast does not ferment all the sugar in the wort, but leaves an average of 1.5 per cent after the principal fermentation, of which about one-half per cent is maltose and one per cent malto-dextrin. (See "Bottom Yeast.")

AN AVERAGE FERMENTATION RECORD.

As indicated by thermometer in degrees F. and R	42 4½	42½ 4¾	43⅓ 5¼	6	48 7	51 8½	51 8½	51 8½	49 7½	46 6½	44 5½	42 4½	40 3½	39 3
By saccharometer in per cent........	13	12$\frac{6}{10}$	12	11¼	10¼	9	7¾	6½	5¾	5¼	5	4$\frac{8}{10}$	4$\frac{7}{10}$	4$\frac{6}{10}$
Period of fermentation in days after pitching	0	1	2	3	4	5	6	7	8	9	10	11	12	13

HIGHER PITCHING TEMPERATURES.

The wort, upon reaching the starting tub, always contains foreign germs which it took up on the surface and Baudelot coolers. Before fermentation starts, these foreign germs will multiply with comparative rapidity, and after fermentation has started, are suppressed the more effectively, the more quickly fermentation reaches the high Kräusen stage, at which the fermenting action of the yeast is at its height, as is the temperature of the fermenting liquid.

The old practice is to cool the wort to 42° F. (4.5° R.) and to allow hours to pass before pitching, sometimes waiting over night. This is not in accordance with scientific principles, and, consequently, Wahl, on the occasion of a convention of the United States Brewmasters' Association, held at Baltimore, prosed the following treatment for use in American breweries:

Refresh and develop the yeast with first wort of 59° F. (12° R.) and put in the starting tub, timing this preparation so that the mass is just beginning to ferment at the moment when the first wort reaches the starting tub from the Baudelot cooler. The wort should run on the yeast, instead of the yeast being put into the wort. The wort is cooled down to 49° F. (7.5° R.) instead of 40-42° F. (3.5-4.5° R.).

When in Kräusen—which will be in 20 to 24 hours instead of 40 to 45 as by the old practice—pump the wort into another vat or distribute among the fermenters. The temperature will have reached 51° F. (8.5° R.) by this time. Keep it at this height by means of "swimmers," or attemperators until the Kräusen have fallen down sufficiently, and cool in about three days down to 39° F. (3° R.), working so that the decrease of the saccharometer in the last 24 hours will not exceed 0.1 per cent.

The advantages of this practice are many:

1. The wort need not be cooled down so low, that is, refrigeration is saved.
2. The wort is ready for pitching sooner.
3. Fermentation sets in sooner.
4. Fermentation is finished 2 to 4 days earlier.
5. The development of the yeast is more vigorous.
6. The yeast remains purer.
7. Less Kräusen are needed, their temperature being higher; or, equal amounts of Kräusen do more work and give more life to the beer in a shorter time than colder Kräusen.

The new practice has met with a speedy recognition, having been introduced with good results in many breweries.

Fermentation of a wort pitched at high temperature:

Thermometer in degrees F. and R.	49 7.5	51 8.5	51 8.5	51 8.5	51 8.5	51 8.5	51 8.5	48 7.0	45 5.5	42 4	39 3
Saccharometer in per cent	13.0	12.0	10.75	9.25	7.75	6.2	5.0	4.5	4.3	4.2	4.1
Period in days	0	1	2	3	4	5	6	7	8	9	10

In Kraeusen in 12—18 hours.

BOTTOM YEAST.

(See also Yeasts and Fermentation.)

The substance, by the agency of which fermentation is carried on is called yeast.

The course of the fermentation as performed by the yeast depends not only on the vitality and environment of the yeast, as age of yeast, temperature, aëration, composition of nutritive medium, presence or absence of other organisms, but also upon the type of yeast employed.

Types of cultivated yeast are distinguished by differences in the following properties possessed, or effects produced, by them:

1. Degree of attenuation;
2. Fermentative energy, or rapidity of attenuation;
3. Reproductive energy, or growth of yeast;
4. Rapidity of settling of yeast, or clarification of beer;
5. Qualities of beer obtained, as taste, odor, and durability. (See "Yeasts and Fermentation.")

The closest attention should be devoted to the yeast, as only by a sound, that is, pure and strong, yeast can a sound beer be produced.

CHARACTERISTICS OF A GOOD BOTTOM YEAST.

It has a thick, stiff, pasty consistency, not watery or slimy, a yellow to brownish color, a bitter taste due to hop-resin, and a characteristic odor.

It consists, for the most part, of single cell organisms of the class saccharomyces and species cerevisiæ. Yeast mechanically encloses a large amount of water, or beer—about 20 per cent—through which are dispersed minute bubbles of carbonic acid gas, that escapes when the yeast is stirred, emitting a rustling sound. After the beer has run from the fermenter, the yeast sediment should be quite firm and thick. However, unless an absolutely pure culture, every yeast has an admixture of foreign organisms, as bacteria, wild yeasts, and mycoderma. All these impurities may be classified as "potentially dangerous."

Since wild yeast or mycoderma cells do not settle so readily as culture yeast, the different layers of yeast in a fermenting vat will not be found generally to contain wild yeast or mycoderma in uniform numbers. Nor is the brewer safe in judging from the absence of wild yeast or mycoderma in the yeast sediment that the beer is free from these obnoxious foreign organisms. Therefore an examination of the beer should always be made at the same time.

There are some admixtures that may be considered "harmless," as hop-resin and proteids, which give a deeper color, and crystals of oxalate of lime. (See "Micro-organisms.")

For microscopical examination of yeast as to strength and purity, see "Microscopical Laboratory."

KEEPING YEAST SOUND AND PURE.

Four essential points are to be considered in this respect. Proper nourishment, proper temperature, sufficient air, exclusion of adverse influences generally.

Neglect of these requisites may necessitate a change of yeast, that is, the introduction of an entirely new yeast by the brewer, the old yeast failing to perform its functions as desired, since the yeast may degenerate and become either too weak or too strongly contaminated to serve its purposes.

WEAK YEAST.

Symptoms of weak yeast are:

1. Watery or smeary condition, due to lack of carbonic acid;
2. Slow settling of the yeast in the vat, in the sample glass, and when watering or washing;
3. Poor "break" of beer;
4. Slow progress of fermentation;
5. Rim fermentation;
6. Rest fermentation;
7. Foxy fermentation;
8. Cold and bare spots in the Kräusen. (See "Abnormal Fermentations.")

It should be borne in mind that abnormal fermentations are not necessarily due to the weakness or impurity of the yeast. A microscopical examination is needed to decide this point.

NOURISHMENT OF YEAST.

The principal yeast foods in beer wort are the albuminoids and certain mineral salts. Of the albuminoids the amides are the most readily digestible, the peptones next, the albumose and insoluble ones not being available at all for this purpose. (See "Nutrition" under "Yeasts and Fermentation.")

Unfavorable conditions of yeast nutrition, that is, such as tend to increase the relative quantity of sugar or diminish the relative quantity of amides and phosphates, may be brought about by the following circumstances:

By using too much of raw cereals or sugar, which enlarges the quantity of sugar in the wort and diminishes the amount of albuminoids and phosphates.

By holding the mash at temperatures favorable to the formation of sugar too long, especially when the malt is rich in diastase.

Employing too high initial temperature whereby the production of amides and peptones is curtailed.

The preventives in these cases are self-evident (see Mashing Methods).

IMPROPER TEMPERATURES.

These may consist in:

Allowing fermentation to take place below 41° F. (4° R.).

Keeping the yeast without fermentation at higher temperatures (above 4° R.).

Changing the temperature rapidly, for instance, pitching cold wort with yeast that was started in a warmer wort.

The proper temperatures for bottom fermentation are 42° F. (4.5° R.) to 51° F. (8.5° R.), or 49° F. (7.5° R.) to 51° F. (8.5° R.). (See also Temperatures under Yeasts and Fermentation.)

AERATION OF WORT AND YEAST.

Yeast requires air to carry on its vital functions. Oxygen should be supplied to the yeast in the wort to hasten fermentation, increase the yeast crop, and prevent degeneration.

Yeast seems to absorb a large amount of oxygen which it holds in reserve and utilizes during fermentation as it needs it. This free oxygen seems to be absolutely necessary for the yeast to carry on fermentation, and if not absolutely necessary for reproduction it certainly stimulates it and has generally a beneficial effect on the yeast. Excessive aëration is to be avoided, however, as under its stimulating effect the yeast may multiply excessively and take a corresponding amount of valuable substances out of the wort, which, like the amides, aid in giving beer fullness of body and foam-holding capacity. (See also Respiration under Yeast and Fermentation.)

Aëration can be supplied by:

Aërating the wort on the surface cooler or the Baudelot cooler.

Aërating the yeast directly, or aërating the wort after pitching, or during fermentation.

In all cases care should be taken to supply the yeast with pure air.

ADVERSE INFLUENCES GENERALLY.

Adverse influences to which yeast is most commonly exposed are:

Frequent washing of the yeast especially with large quantities of water, or soft water.

Long duration of fermentation.

Letting the yeast stand under the beer or water too long.

Keeping yeast in an inactive state too long from one fermentation to another.

Employment of salicylic acid or other antiseptics in excessive quantities.

(See also Influence of Fermentation Products under Yeast and Fermentation.)

STRENGTHENING THE YEAST.

A yeast that has become weakened may be strengthened by one of the following methods:

BY FERMENTATION IN MALT WORT.

It should be put through fermentation in a pure malt wort from time to time. This is the most appropriate remedy where an excess of sugar in the wort is the cause that weakened the yeast.

ADDITION OF SALTS.

Certain salts like phosphate of potash and others may be unobjectionable for strengthening yeast when added while the yeast is being refreshed and developed for pitching. However, in view of the possible injury that can be done by addition of a wrong substance by mistake, it is best to avoid chemicals in any form.

DRUGS TO BE AVOIDED.

Many articles were used in former times in this connection, and there was much occult knowledge pretended to by brewers concerning them. Among these articles were nutmeg,

anise, cloves, saffron, cardamom, grains of paradise, coriander seeds, orris root, bay leaves, etc.

These and similar admixtures are for the most part quite indifferent, and in some cases injurious. They impart to the beer a peculiar odor. They should never be used.

The same may be said of alcohol or spirits.

Neither should malt flour be used in this connection, since such flour always contains bacteria. Nor does malt flour tend to strengthen the yeast. On the contrary, the diastase it contains, by changing the dextrin to maltose, increases the relative amount of sugar. There will, accordingly, be a higher degree of attenuation, accompanied by a tendency to weaken the yeast.

YEAST WATER OR BOUILLON.

A yeast water or yeast bouillon, or soup, may be used to advantage for strengthening purposes. To prepare it, boil six gallons of yeast with six gallons of water for half an hour, cool, let settle, pour off the yeast-water, about one-half of whole quantity, boil until flavor becomes agreeable, which may take a few hours, and add to six gallons of yeast, together with six gallons of first wort of a temperature of about 59° F. (12° R.), or finished wort. The active elements for the present purpose in this solution are large quantities of phosphates of potash and amides. (U. S. Patent of June 4, 1895, issued to R. Wahl and M. Henius).

ABUNDANT AERATION.

Finally, abundant aëration should be provided for the wort on the surface or Baudelot cooler, in the collecting or starting tub, before and just after pitching, or while refreshing the yeast for pitching. This aëration is not to be continued after the beer has come into Kräusen.

CONTAMINATIONS OF YEAST.

The principal agents of contamination are bacteria, mycoderma, and wild yeast.

Such contamination may be indicated in the brewery by: (1) Bad odor of fermentation. (2) Bubble fermentation. (3) Foxy fermentation. (4) Ropy fermentation. (5) Improper clarification of the beer in sample glass or chip cask. (6) Bad odor and taste of finished beer. (7) Impaired brilliancy and durability of the beer.

Foreign organisms reach the yeast from the air, from drippings from ceilings, through unclean vessels or utensils with which beer comes in contact. There is danger of infection wherever unfiltered air is permitted to reach the wort or beer, or where vessels are left uncovered, as fermenters, affording an opportunity for foreign matter to drop in.

Cleanliness, therefore, of the most scrupulous and exacting kind, is a prime necessity and the safest precaution for keeping yeast pure and sound.

SAFEGUARDS AGAINST CONTAMINATION.

Run the wort from the surface cooler as soon as it has cooled to 145° F. (50° R.). To leave it on the surface cooler after that point has been reached is to promote the development of foreign ferments, which have easy access to the beer, owing to the great surface exposure, and multiply rapidly at favorable temperatures, from 145-77° F. (50-20° R.). The air in the cooler rooms should be as pure as possible. Malt dust, street dust, etc., may become very dangerous at this point.

High fermenting varieties of yeast are not infected so readily as low fermenting.

Pitch with yeast directly after cooling.

Keep the yeast cool by attemperators or "swimmers" or brine pipes, never directly by addition of ice, which often contains impurities.

Protect the yeast, beer and wort from contact with impure air.

Prevent the drippings from the ceiling of the surface cooler room, and of the fermenting cellar, getting into the wort or beer. Protect the beer by inclined covers of canvas, wood or sheet iron hung over the fermenting vats.

Observe the strictest cleanliness. Thoroughly clean all pipes, conduits, vessels, floors, walls, etc. (See "Cleansing Operations.")

Low temperature is another important safeguard. The temperature should be kept down as much as practicable in all cellars.

NATURAL PRESERVATIVES.

Besides cleanliness and low temperatures, alcohol, carbonic acid, lactic acid and hop-resin are the natural perservatives of the yeast and beer, among which alcohol has special importance (See "Yeasts and Fermentation.")

TREATMENT OF CONTAMINATED YEAST.

Unless contaminated beyond hope of recovery, a yeast may be purified by the following means:

WATERING.

This may be used if the number of bacteria approximates 15 to 30 per 1,000 yeast cells.

Application: To 50 pounds of yeast add two gallons of pure cold condensed water, unless the natural water is absolutely above suspicion, to which has been added one ounce of gypsum (plaster of Paris). Stir well and pass through a very fine sieve—hair sieve—allow to settle while cooling by means of attemperator or brine pipes, never by adding ice. Pour off the water.

If the number of bacteria exceed 30 per 1,000 yeast cells, a change of yeast should be resorted to.

HIGHER FERMENTATION TEMPERATURES.

By employing higher pitching temperature or allowing the temperature to rise higher during fermentation, the culture yeast is enabled more effectively to rid itself of mycoderma or wild yeast or bacteria. (See "Yeasts and Fermentation.")

PURE YEAST CULTURE.

Several cells are separated from the rest under the microscope, the most suitable selected and propagated, according to the methods of Hansen, avoiding with absolute certainty infection from all possible causes, besides assuring the maintenance of the typical character of the yeast required for the desired fermentations, (See Pure Yeast Culture).

FACTORS AFFECTING FERMENTATION.

Fermentation, as has been repeatedly explained, is subject to modification by various factors, the most important of which are:

1. Amount of maltose;
2. Temperature,
   a. at time of pitching,
   b. as it rises during fermentation;
   c. time of holding highest temperature.
3. Amount of pitching yeast;
4. Condition of pitching yeast, whether weak or strong;
5. Type of yeast, whether of high or low attenuating power, whether slowly or quickly settling;

6. Aëration;
7. Presence of foreign bodies (abnormal fermentation).

DIFFERENCES IN ATTENUATION.

The effects of these factors on practical brewing operations may be again briefly considered.

(a) The larger the amount of maltose in the wort, (b) the higher the fermenting temperature, (c) the longer this temperature is maintained, (d) the stronger the yeast, (e) the stronger the aëration—(A) the higher will be the attenuation, (B) the greater will be the amount of alcohol in the beer, (C) the less will be the percentage of extract remaining in the beer.

The attenuation is also influenced by the amount of malto-dextrin in the wort.

Where a wort is very rich in sugar (sugar to non-sugar = 100:20, or sugar percentage 83.3), the saccharometer indication may fall from 13 B. to 2 B. Where the wort is unusually poor in sugar (sugar to non-sugar = 100:80, or sugar percentage 55), the saccharometer will fall from 13 B. to 6 B., and with abundant aëration, high temperature, and yeast of high attenuating type and extraordinary vigor, may be brought down to about 4¾ B. Attenuation depends, however, mainly upon the amount of sugar, and, secondarily, on the type of yeast employed.

The residue of sugar left in the wort at the end of the principal fermentation generally amounts to one-half per cent of maltose and 1 per cent of malto-dextrin for worts of average original gravity or about 10 per cent of the original extract. A yeast of high attenuating type, like Frohberg, gives an apparent degree of attenuation, which is about 10 per cent higher in a beer of ordinary gravity than where a yeast of the Saaz type is employed, other things being equal.

The difference in attenuation resulting from the employment of different yeast types is supposed to be due to the presence of an enzyme in the yeast of higher attenuating power, which has the property of inverting malto-dextrin to dextrose, whereas the yeast of low attenuating power does not contain this enzyme, or contains it in a smaller quantity or lower degree of activity. (See also Yeasts and Fermentation.)

An addition of malt flour to the beer or yeast increases the attenuation, because the diastase of the malt flour inverts the dextrin of the beer, during fermentation, to maltose, which then ferments. This addition cannot be recommended on account of the danger of contamination, the malt flour containing many bacteria from the malt husks.

DURATION OF FERMENTATION.

(a) The higher the pitching temperature, (b) the higher the fermentation temperature, (c) the better the aëration, (d) the stronger the yeast, (e) the larger the quantity of yeast added, (f) the lower the percentage of sugar in the wort—the shorter will be the period of fermentation.

(a) The higher the pitching temperature, (b) the better the aëration, (c) the stronger the yeast, (d) the larger the quantity of pitching yeast—(A) the quicker will the beer go into kräusen, (B) the quicker will the saccharometer indication fall, (C) the quicker will the fermentation reach the high Kräusen stage, (D) the higher will the Kräusen rise.

FERMENTATION TEMPERATURE.

(a) The higher the pitching temperature, (b) the higher the percentage of sugar, (c) the stronger the yeast, (d) the greater the quantity of pitching yeast, (e) the better the aëration—the higher will the temperature of fermentation rise.

QUANTITY OF YEAST.

For every 100 pounds of extract fermented, about 15 pounds of new yeast is produced. Part of the yeast, equaling about one pound per barrel, goes with the beer on ruh, about 1 pound of yeast per barrel of beer is wasted, being the top and bottom layers of the yeast sediment, while 1 to 2 pounds per barrel is obtained of a quality suitable for pitching.

The better the aëration, the larger the percentage of sugar fermented, the more vigorous the yeast—the greater will be the new yeast crop.

The smaller the quantity of pitching yeast, the greater will be the amount of new yeast developed, since a small quantity of pitching yeast will yield as large a yeast crop as a large quantity.

INFECTION.

(a) The longer the wort stands without yeast, especially at higher temperatures, (b) the smaller the quantity of pitching yeast, (c) the weaker the yeast—the more favorable are the conditions for the development of foreign ferments.

HIGHER PITCHING TEMPERATURES.

The danger of infection is greatest before fermentation becomes active, since after the energetic action of the yeast has set in, foreign ferments have less freedom of development. It is therefore desirable to have the Kräusen rise as quickly as possible. This can be accomplished by pitching at higher temperatures than was customary in former years, starting at 49° F. (7.5° R.).

ABNORMAL SYMPTOMS IN FERMENTATION.

COLD OR BARE SPOTS.

In the stage of low Kräusen the entire surface of the beer is not always covered, but there may be openings in the head of foam.

The cause is weak yeast, or conditions tending to bring about a lowering of the temperature at the surface, like a cold draught of air.

BLADDERY OR BUBBLE FERMENTATION.

Large bubbles may be seen in the kräusen while they are collapsing.

Cause: Large amounts of finely divided suspended matter like starch, proteids and bacteria. When beer contains too little hop-resin, bubble fermentation may show more readily.

REST FERMENTATION.

In this case fermentation progresses but slowly and comes to a standstill while the indication of the saccharometer remains very high.

There may be several causes. 1. Too low a percentage of sugar in the wort. It may occur where the original Balling of the wort is high, but the ratio of dextrins is excessive. To prevent this, change the mashing method. To restore the defective wort to a normal condition, fill the fermenting vats half full with "green" beer just coming into Kräusen, and pump the beer showing rest fermentation to the Kräusen beer, adding one quart of cold extract of malt (for preparation see Starchy Turbidity of Beer), for every 50 barrels of beer. The diastase of the malt will first invert the dextrin and make the new sugar amenable to the influence of the yeast.

Cause 2 may be weakened or degenerated yeast, usually caused by too high a percentage of sugar in the wort, together with a lack of amides and mineral substances. To prevent its recurrence, change the yeast and the method of mashing. To save the beer that suffers from rest fermentation due to this cause, mix it with equal parts of fresh Kräusen beer, without adding any malt extract.

BOILING FERMENTATION.

When the Kräusen begin to fall, the head of foam sometimes disappears, and the beer seems to boil up from the lower side of the fermenting vat, the bubbles of carbonic acid drift swiftly across the surface to the opposite side, the beer in the vat has gone into a rotary motion.

Cause: Unequal distribution of the yeast at the bottom of the fermenting vat, generally due to a strong inclination of the vat, and most frequently when the wort contains large quantities of sugar, also when the pitching temperature was too low, and too small a quantity of yeast is employed. An unequal distribution of yeast may be caused by rough wood or the presence of any foreign body in the vat.

Treatment: Rouse the yeast well from the bottom of the vat. A dressing with malt flour or common salt, which is sometimes recommended, is of no value. To prevent this abnormal fermentation occurring again, adopt another mashing method if the wort contains too much sugar, pitch at higher temperatures, and use more yeast.

RIM FERMENTATION.

After the Kräusen have fallen down, a rim of foam appears around the sides of the vessel, and the beers do not settle well.

Cause: Yeast clings to the walls of the fermenting vat, either because of a weak condition of the yeast, or because the wood is rough or not properly planed and varnished. Another cause is too rapid cooling of the beer before the Kräusen have properly collapsed, leaving too much sugar, which the yeast continues to ferment.

FOXY FERMENTATION.

The beer retains a muddy and reddish appearance, and will not settle.

Cause: Weak, light yeast, or wild yeast, or mycoderma, or much suspended matter of any kind, as starch, proteids and bacteria. Another possible cause is that the beer may have been cooled too quickly, when it still contained large quantities of sugar, the continued generation of carbon-dioxide keeping the lighter particles in suspension.

ROTTEN FERMENTATION.

This manifests itself by a foul odor arising from the fermentation, which is best observed by blowing into the Kräusen head.

Cause: Infection by bacteria of putrefaction. (See "Contaminations of Yeast.") For treatment see Bacteria Turbidity.

ROPY FERMENTATION.

In top fermenting beers. The beer becomes stringy or ropy.

Cause: Infection, usually by bacillus viscosus.

VACUUM FERMENTATION SYSTEM.

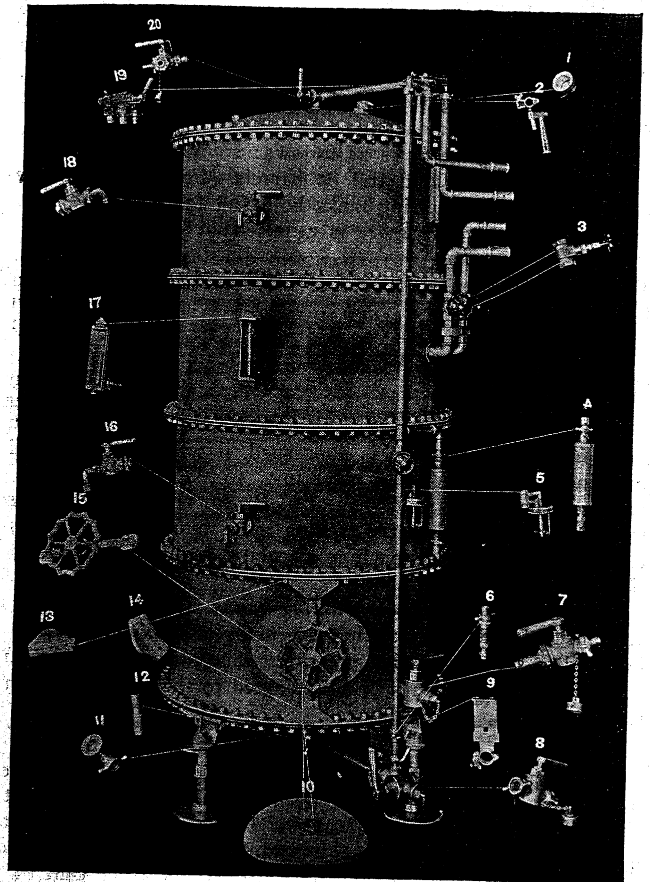
The important features of this system are:

1. The fermentation is conducted in closed glass enameled steel tanks, avoiding necessity of varnishing.
2. There is no contact with the atmosphere.
3. Sterilized air only is admitted, under perfect regulation during the fermentation.
4. Fermentation being conducted under a partial vacuum, there is a continuous removal of carbonic acid gas as fast as generated, which, together with admission of sterilized air, causes a continuous rousing of the beer.
5. The fermentation is completed within seven days from the kettle.

VACUUM FERMENTATION PLANT AND FITTINGS.

The special apparatus used in the vacuum fermentation system are as follows (see illustration):

1. Beer inlet with cap.—2. Pipe support for three-way fixture.—3. Gate valves for attemperator connections.—4. Air filter.—5. Air sight feed with glass.—6. Air check and stop cock.—7. Racking cock with strainer (formerly called spring racking valve).—8. Racking-off cock with cap and chain with half-inch air pipe connection.—9. Bracket for yeast valve support.—10. Manhole cover.—11. Beer outlet for bottom elbow.—12. Yeast strainer.—13. Top or large ear for manhole crab.—14. Bottom or small ear for manhole crab.—15. Crab, wheel and screw for manhole plate.—16. Testing cock with rubber nipple.—17. Thermometer.—18. Air cock with elbow for hose connection.—19. Three-way fixture for vacuum, gas and air connections.—20. Top cask connection. The half-inch valve in the air pipe just above the air sight feed fixture is not shown in the marginal fittings, nor is the testing glass (bottle), used on testing cock.



Vacuum Fermenter.

The dimensions of the tanks are as follows:

Inside diameter of all tanks, 7 feet 6 inches.—Outside diameter of all tanks, 8 feet.—Dish of tops and bottoms, 10 inches.—Height of each ring, 30 inches.—Height of legs, 18 inches.—Bottom of tank above floor, 7 inches.—Height of tank over all, three rings, 10 feet 2 inches.—Height of tank over all, four rings, 12 feet 6 inches.—Height of tank over all, five rings, 15 feet 3 inches.

The *capacity of tanks* is as follows:

Three-ring tanks hold full 85 barrels.—Four-ring tanks hold full 110 barrels.—Five-ring tanks hold full 135 barrels.

The following *cellar space* is required:

WEEKLY FERMENTING CAPACITY.

Three-ring tank	70 barrels
Four-ring tank	90 barrels
Five-ring tank	110 barrels

WEIGHT OF TANKS.

Three-ring tank	4,500 pounds
Four-ring tank	5,500 pounds
Five-ring tank	6,500 pounds

As far as *refrigeration* is concerned, it will then require ice-machine capacity over the cooler to 7° to 7½° R., for cooling the vacuum cellar 22,000 cubic feet at 6° R., for cooling the beer, say, to 1° R., and for cooling the racking-room as usual. Estimates by experts place the ice-machine capacity required, complete, at thirty tons for such a plant.

The chip tanks and carbonating tanks are the same as the vacuum tanks, except that they are made of heavier steel and reinforced to stand excessive pressure. The fittings of these tanks are also of bronze, and specially adapted to their purpose. These tanks are steel, glass enameled.

FERMENTATION.

The preparation of the wort is identical with the method employed for wort intended for open fermentation. The wort is cooled to 46° to 49° F. (6½° to 7½° R.), and run into the starting tub or directly into fermenting tank. Yeast is added as soon as cooling is commenced, and the quantity is 3 per cent of the total extract in wort in pounds, or about ¾ to 1 pound per barrel. The temperature of the fermenting cellar is 43° to 48° F. (5° to 7° R.). If the wort has been run into an ordinary starting-tub, it is run or drawn by vacuum into the fermenter as soon as the Kräusen appear, generally in 12 to 16 hours. If the wort has been run into the fermenter directly from the cooler it need not be drawn into another fermenter until the final stage of fermentation. The fermentation may also be finished in one fermenter only, if desired. When the beer has been collected in the fermenter, the vacuum is regulated to 15 to 18 inches, and this is maintained during the fermentation. The amount of filtered air desired to be passed through the fermentation can be exactly regulated and observed. The amount of air and the time for which it is to be admitted depend upon various conditions. The general practice is to admit the filtered air as soon as 15 to 18 inches of vacuum has been reached in the fermenter. The admission of air is continued generally for 48 to 96 hours. The temperature of the fermentation is allowed to rise to 51° to 53° F. (8½° to 9½° R.), depending on conditions and results desired. When about 90 to 95 per cent of the final apparent attenuation has been reached, lowering of the temperature is proceeded with in the usual way. The vacuum is maintained until the saccharometer indications remain stationary for six hours, when the vacuum is relieved by allowing filtered air to enter at the top of the fermenter. The fermented beer is allowed to rest from 24 to 48 hours, for the yeast to settle out, and for cooling to the desired temperature before running into the chip-casks, which is generally 36° to 39° F. (2° to 3° R.).

SAMPLE FERMENTATION.

	Wort at Pitching in Starting Tub.	1st Observation. At Kräusen Stage. 14 Hours. Drawn Into Vacuum Tank.	2d Obs. 38 Hrs.	3d Obs. 62 Hrs.	4th Obs 86 Hrs.	5th Observation. 110 Hours. Drawn Over Into Other Fermenter.	6th Obs. 134 Hrs.	7th Obs. 158 Hrs.
Temperature.	7½° R.	7¾	8¾	9	8¼	7½	6	3½
Per Cent. Balling	13.2% B.	12.8	10.5	7.3	5.2	4.1	4.0	4.0
Vacuum	....	15 to 16 In. Applied.	On	On	On	On	Off	Off
Air	....	On	On	Off	Off	Off	Off	Off

ON CHIPS.

The treatment on chips is identical with that now in ordinary practice for stored beer. If the beer is intended for carbonating, it is cooled to 33° to 32° F. (½° to 0° R.), and this temperature maintained for 48 to 96 hours, depending upon the composition of the beer and the character of the yeast that has been employed in its fermentation. After being held at so low a temperature for the necessary time, it is filtered. Care must be taken that the temperature does not rise during filtration. The filtered beer is then forced through the carbonator and charged with the gas collected during the fermentation, and is then stored for 12 to 24 hours in a cask under pressure, and then racked off.

COLLECTING CARBONIC ACID DURING THE FERMENTATION.

About 12 to 24 hours before starting to collect gas the air is shut off, but the vacuum kept on. The vacuum-pump conveys the gas to a small cylinder. When the gas pressure in this cylinder reaches about 3 to 4 pounds, this pressure opens the steam valve to the compression pump. This pump forces the gas into steel cylinders to a pressure of 150 pounds, or more, if desired. If the gas pressure in the small cylinder falls below 3 pounds the steam valve on compression pump closes. In this way the gas collection works quite automatically.

CARBONATING.

The desired gas pressure in the carbonator, generally 23 to 25 pounds, is regulated by a reducing valve between the gas storage tanks. The back pressure on the carbonated beer is generally about 15 pounds. Of course, the pressures vary according to the desired quantity of carbonic acid gas the carbonated beer is to contain.

STORAGE CELLAR OPERATIONS.

The beer is ready for tanking when the principal fermentation is virtually finished. The marks by which that stage can be detected are the following:

1. Decrease in the indication of the saccharometer should still be from $\frac{1}{10}$ per cent to $\frac{1}{20}$ per cent during the last 24 hours.
2. The beer should have a good cover of fine, more or less dark foam. This protects the beer from contamination by contact with cellar air; therefore the cover should not be skimmed off more than once during or after the collapse of the Kräusen.
3. The temperature of the beer should be 39° F. (3° R.). This temperature is brought about by attemperators in the fermenters, or by running the beer from the fermenter to the storage vat through a cooler.
4. The beer should show a good break in glass. Held against the light, the small sample glass should show a lumpy condition of the yeast, balled up in little clots, between which the liquid in a thin layer should show translucent.
5. The yeast should settle in the sample glass at cellar temperature within 24 hours, the beer becoming entirely brilliant. The yeast should not settle on the sides of the glass. In a warm room it ought to settle in 3 to 4 hours.
6. The beer should look black when the cover is blown aside, showing that the yeast has settled well and left the liquid comparatively clear.
7. The beer should still contain some sugars, i. e., should not be completely fermented, in order to enable secondary fermentation to take place. During the previous 24 hours before tanking there should still be a slight attenuation.
8. Beer for export purposes—bottle beer—should not be allowed to settle too much, but rather be racked "green" than clear ("lauter").

Before running the beer into the storage vats, the foamy head should be skimmed off with care, and then the liquid pumped without the least concussion or agitation of any kind.

The beer should be distributed into different Ruh tanks in order to secure a more uniform product both as to appearance and taste.

ON STORAGE ("RUH").

Storage, "Ruh," is that stage in which the beer is kept after the conclusion of the primary fermentation and prior to final clarification for the trade package.

The objects of resting the beer are to eliminate certain suspended matter, like yeast, securing greater clearness, and certain objectionable matters, like proteids, securing greater durability, especially in pasteurized bottled goods.

During the "Ruh" or storage period there should be a slight progress of secondary or after-fermentation. The residue of maltose and part of the malto-dextrin are fermented by slow degrees, the amounts of carbonic acid and alcohol increasing.

The yeast settles the more quickly, the less sugar there is present and the smaller the storage vats; and proteids are the more thoroughly eliminated, the better the mash was peptonized, the lower the storage temperature, and the longer the period of storage. Hence, long storage at low temperatures enhances the stability of beer after pasteurization.

Starch particles do not settle on Ruh. Nor can dependence be placed on improving the beer through long storage in respect to number of bacteria it contains. On the contrary, bacteria may increase during storage.

Low temperature, while the beer is in storage, is necessary to precipitate the proteids and to check the development of bacteria.

Keep the storage cellar as near to 32° F. (0° R.) as possible.

If the beer becomes brilliant on Ruh, that is, if after-fermentation comes practically to a standstill, bacteria will develop more easily.

If the beer is to be stored for a long time it should not be allowed to become so clear in the fermenting vat as when an ordinary beer is produced, but should be run into storage casks while still "green."

If the beer becomes clear on storage and we intend to store it longer, it should be kräusened with 3 to 5 per cent of Kräusen beer

and pumped into another Ruh tank. Another plan is to let the principal fermentation proceed as far as usual, and subsequently run in some Kräusen beer while the beer flows to the storage vats. This plan is recommended for beers designed to be very brilliant and remain in protracted storage.

If it is desired to bring the beer quickly on the market (city beer), add chips to the storage beer and also isinglass for preliminary fining.

For bottle beer, a high attenuating, slowly clarifying yeast should be employed.

For keg beer, a low attenuating, rapidly clarifying yeast is more suitable.

Export bottle beer should be stored three months; export draught beer six weeks.

During the storage period, hop-oils are partly converted into resins, the hop aroma diminishing accordingly.

CHIP CELLAR OPERATIONS.

THE BEER IN THE CHIP CASK.

When sufficiently matured in storage, the beer is run or pumped into chip casks, so called from a method of clarifying beer by means of chips (which see).

Treatment in the chip cellar has a twofold object.

1. To impart to the beer the necessary life, that is, a sufficient amount of carbonic acid gas so that it will foam properly when tapped. This is done—
   - a. by kräusening and bunging, or
   - b. by charging with carbonic acid gas directly (carbonating); or
   - c. by both kräusening and carbonating.
2. To make the beer brilliant. This is done—
   - a. by the addition of chips.
   - b. by the addition of isinglass.
   - c. by filtration.

KRAEUSENING.

This consists in the addition of Kräusen beer, that is, young beer in the first, or Kräusen, stage of fermentation, 24 to 44 hours after pitching, according to pitching temperature and amount of pitching yeast used. As to amount of extract and other constituents it differs but little from fresh wort, hence it changes the composition of the ripened beer. While the addition of Kräusen beer will cause fermentation to continue in the chip cask owing to the presence of fresh yeast, all of the sugar introduced by it will not be fermented.

The effects of kräusening, therefore, are:

1. The kräusened beer will have a higher percentage of extract, especially sugar. This has the effect of impairing the durability of draught beer, sugar being favorable to the growth of yeast.

2. The kräusened beer will contain a larger amount of hop-resin, the taste of the beer is accordingly changed, Kräusen beer being sweeter on account of sugar and more bitter on account of hop-resin.
3. The kräusened beer will contain more proteids which will impair the durability of bottle beer. Use sugar Kräusen for bottle beer.
4. The kräusened beer will contain a smaller percentage of alcohol.
5. The temperature of the beer will be raised slightly owing to the revival of fermentation and the higher temperature of the Kräusen.
6. Carbonic acid will be generated by the continued fermentation in the chip cask, which gas accumulates in the beer after bunging.
7. Young yeast cells are added.

The more energetic the cask fermentation, the more easily will the beer clarify. The young, vigorous yeast cells readily form clusters or lumps of yeast which will envelop, and, upon settling, carry down with them the smaller ones, together with bacteria and other suspended matters; thus, in part, at least, promoting clarification.

Kräusening is based on a principle similar to that which leads English brewers to "prime" beer in the trade casks by adding a strong solution of cane or invert sugar.

AMOUNT OF KRAEUSEN.

This is governed by the properties desired in the finished beer.

For shipping beers—draught and bottle beer (steamed)—that is, beers of which durability is required, not more than 8 to 10 per cent. For common draught beer, 15 per cent of Kräusen is generally used. These amounts vary, however, with the demands of the trade. In some cities as much as 25 per cent of Kräusen is added regularly to the city beer.

Where the taste is too bitter, use more Kräusen with less hops. Where the taste is flat, also use more Kräusen, but have them hopped as usual. If a beer is stubborn of clarification use more Kräusen.

Let the Kräusen foam work out of the bung-hole for three or four days. If the beer is bitter, continue for eight days.

The formation of a Kräusen cap over the bung-hole indicates that the Kräusen are working properly.

CLARIFICATION OF BEER.

Matter remaining in suspension at the end of the storage period is eliminated by mechanical means. First among them is the introduction of chips.

BEER CHIPS.

"Beer chips" or "clarifying chips" are pieces of wood so cut as to present a maximum of surface with a minimum of volume and weight.

Chips are made of varying lengths, breadth and thickness. Some brewers favor the very thin, curly chip, others prefer the straight, thicker and smooth chip, others again the corrugated chip. Metal chips have also been introduced, but since it is known that certain metals will produce cloudiness in beer, they should be employed with caution.

The chips clarify through the force of adhesion exercised by the surfaces of the same upon the small particles of matter suspended in the liquid.

PREPARING CHIPS.

Chips from young hardwood, beech or maple, are more effective than chips from old or soft wood. The wood should be well seasoned, i. e., well dried before cutting it into chips. The chips should then be boiled in plenty of water to remove coloring matter and woody taste, and one pound of soda is taken per barrel of water to remove the resin and make the wood more porous. Boil again with one-half pound of soda per barrel, a third time with one-quarter pound per barrel, then with water alone. If, after boiling for some time, the water remains colorless and without taste, and reacts neutral, the chips, after cooling, are ready for use in the chip cask.

Beer can be run twice on the same chips without removing them, then take them out and wash with cold pure water. After running beer on them twice again, wash them, first with cold water, and then with hot water, or boil them.

If the beer is infected, the chips must be removed each time after racking, and boiled each time after washing with cold water.

If chips that have been used are to be dried, they should previously be well washed and sprinkled liberally with a solution of bisulphite of lime.

NUMBER OF CHIPS USED.

The number of chips to be put into the beer depends largely upon the degree of haziness of the beer. As a rule, the number should be the greater, (1) the younger the beer, (2) the more particles in suspension, (3) the finer the particles in suspension (bacteria, proteids), (4) if no filter is employed, (5) the larger the quantity of isinglass employed. Without filter the number of chips need not be more than 50 per barrel. If beers clarify with difficulty, use double that amount. With filter, use 5-20 chips per barrel, according to size of chip cask.

FINING THE BEER.

The process of brightening which proceeds naturally in storage, is further assisted artificially by fining the beer by means of substances which will rapidly precipitate suspended matter.

For this purpose prepared substances that contain animal gelatin are used. Such substances are obtained from fish sounds or from calf hide.

ISINGLASS.

From Fish Sounds.—These are the cleaned and dried swimming bladders of fish generally, principally of the sturgeon family; in the United States, from the hake. In the process of manufacture, they are first soaked in water, then rolled, and in rare instances starch is added for better appearance—gloss—and finally dried. This isinglass comes into the market in the form of thin shreds or ribbons. It varies in color from a deep yellow to almost white. There should be no odor or taste indicating decay.

From the Hide of the Calf.—This isinglass is manufactured according to Wahl's process. (See Brewing Materials.)

PREPARING THE FININGS.

There are two principal modes of preparing the article, as supplied by the dealer, for use in the brewery.

Warm Preparation.—Soak one pound of isinglass in 1½ gallons of cold, pure, soft water, renewing the water until every trace of odor has disappeared, washing the isinglass in the meantime by rubbing it lightly. At the expiration of about an hour add one-fourth pound of tartaric acid—for fish sounds—and keep stirring until no lumps are left. Add an equal quantity of boiling water, rouse well, mix with an equal quantity of beer, stirring to an intimate mixture, pour into the bung-hole of the chip cask, and stir gently.

With the tartaric acid the isinglass ought to swell considerably, and readily dissolve in the hot water. It is not advisable to dissolve it by steam, or to boil it, as the heat destroys the isinglass rapidly, particularly in the presence of acid.

Cold Preparation.—Soak in cold water and add acid and hot water, the same as for the warm preparation. When dissolved, add four gallons of cold water, rouse well; add gradually more water, and repeat this at intervals for 48 hours, adding as much water as the isinglass will take up. A good quality will take 30 gallons of cold water and keep its gelatinous consistency. This solution is mixed with beer, poured in through the bung-hole, and the beer stirred.

The isinglass may also be gradually thinned down without previous solution by adding small quantities of cold water until up to 30 gallons are obtained.

When using the cold process an addition of sulphite of soda should be made as the gelatinous mass is likely to mould.

Sounds.—If the sounds themselves are used in the brewery, they are soaked in cold water which is poured off, after softening. Then add one-half pound of tartaric acid per pound of sounds; when well softened cut up by passing through a sausage machine. Add cold water gradually, allow to soak thoroughly, and prepare warm or cold as above.

Wahl's Process Isinglass.—This does not call for tartaric acid, but after properly soaking in cold water (one pound per one and one-half gallons) for one hour, should be dissolved in hot water, after which it may be treated on the warm or cold plan like fish isinglass.

OPERATION OF ISINGLASS.

The process by which the isinglass acts is as follows: The gelatin contained in the isinglass dissolves in warm water and precipitates in flakes when cooled in beer when the solution is sufficiently thinned out, but in lumps, when the solution is too concentrated—therefore the cold preparation is more effective than the warm. The flakes gather up the particles in suspension, carrying them upwards during the escape of carbonic acid gas—

before bunging—and settling to the bottom with them, after bunging.

Prepared warm, the finings contain the gelatinous matter in true solution which, on addition to the beer, becomes insoluble, and settles in the form of a net enveloping the suspended particles and carrying them to the bottom, leaving the beer bright.

Prepared cold, the gelatinous substances are only in suspension and very minutely distributed, being insoluble in cold water. The more and the thicker a jelly the isinglass yields, the better is its quality for brightening the beer.

The quantity of finings to be used is dependent upon the extent and stubbornness and the nature of turbidity, and whether a filter is employed or not. Without a filter, use one pound to 40 to 60 barrels prepared warm, or one pound to 100 to 150 barrels prepared cold. When using a filter, one-half of this amount will be sufficient.

BUNGING.

After fining, the beer is bunged, that is, the bung-hole of the chip cask is closed tight for the twofold purpose of enabling the secondary fermentation which has been going on all the time, to charge the beer with the requisite amount of carbonic acid gas, and of promoting the sedimentation of whatever particles may still remain to cause turbidity.

If a bunging apparatus is used, the beer is usually bunged directly after adding the isinglass. If not, it is bunged as soon as it has become moderately fine.

After bunging, the carbonic acid gas generated in the chip cask cannot escape. The beer grows richer in carbonic acid gas and exerts a pressure on the inside of the cask. The more carbonic acid is generated, the higher will the pressure rise. The higher the bung pressure, the colder the beer, and the higher the percentage of extract, the more carbonic acid will accumulate in the beer.

The augmenting pressure in the chip cask facilitates the precipitation and settling of particles in suspension.

When not using racking apparatus, beer should be bunged with from 4 to 5 pounds' pressure, and rather less with racking apparatus. If the beer is bunged with more than 5 pounds' pressure it is apt to foam, if not very cold, when racking.

If the beer contains too much carbonic acid gas it will not hold the foam so well as if it had its proper quantity. If the beer contains too much carbonic acid gas the individual bubbles that make up the foam will be larger than if the foam is creamy, and breaking up more easily, the foam will collapse quicker.

RACKING.

The finished beer is racked off, that is, run into the trade packages (barrels, kegs, etc.).

This is done by means of air pressure, the racking bench usually standing higher than the chip cask, a steady flow of beer under an invariable pressure should be maintained, avoiding jars or concussions, sudden stoppages, etc., as otherwise too much carbonic acid gas will be lost and the yeast might rise in the chip cask, making the beer turbid.

The quantity of carbonic acid gas that beer contained at various stages was found to be (laboratory of Wahl & Henius):

After principal fermentation	0.20 per cent.
After two months' storage (in lower layers)	0.35 per cent.
After racking from storage in chip cask	0.28 per cent.
Before racking from chip cask......	0.40 to 0.42 per cent.
In the kegs	0.35 per cent.
In the glass	0.28 per cent.

If the beer contains less than 0.30 per cent of carbonic acid in the keg or bottle, or less than 0.25 per cent in the glass, its taste will be flat.

There are modern devices for preventing foaming while racking by maintaining a counter-pressure on the flowing beer, yielding to the forward pressure sufficiently to allow the liquid to flow, but offering too much resistance to allow foaming. This is applied both to kegs and to bottles. In some cases the counter-pressure is exerted by carbonic acid, preventing contact of the beer with atmospheric air until the trade cask is tapped, thereby minimizing the chances of infection and adding to the stability of the product.

CHILLING THE BEER.

It is advisable, whether a racking device is used or not, to chill the beer on its way from the chip cask to the filter, reducing the temperature of the beer below the freezing point of water. If beers contain an abnormally high percentage of proteids the low temperature may render them insoluble, when the filter may remove them, this process yielding a more stable beer when bottled and steamed. If beers contain but little proteids the time of passage through the cooler is too short to precipitate any appreciable amount of them.

CARBONATING.

By charging the beer with carbonic acid (carbonating), the detrimental influences of kräusening are avoided. It is difficult, however, to treat beer uniformly according to this method, or to produce beer with creamy head without addition of Kräusen or sugar solution at the same time.

The carbonic acid in carbonated beers is generally introduced into the beer on its way from the chip-cask to the filter. It has been found impracticable, if not impossible, to carbonate Ruh beer from the storage tanks directly, one reason being that in such beers the carbonic acid is not uniformly distributed, the amount being larger in the bottom than in the top layers. In order to be successfully carbonated the beer is usually run into a chip cask where a small percentage of Kräusen is added, and after bunging long enough to raise a slight pressure it is passed through the carbonator.

FILTRATION.

The latest and a most efficient artificial aid to clarification is the beer filter (see filters). It has come into general use of late years. The beer to be filtered need not be so brilliant in the chip cask as where no filter is used.

The process of filtering beer consists in forcing the beer, generally by means of air pressure applied at the chip cask, through one or more layers of compressed fibrous material, called filter-mass, which commonly consists of wood pulp or paper pulp. The thicker the layer of pulp, and the stronger it is compressed, the more effective will the filter be in removing turbidities, but the slower will be the process of filtration. By means of filtration yeast cells, both of culture yeast and the different varieties of wild yeast, and mycoderma cells can be removed. If the filter material is of fine texture (mixed with asbestos fiber) and compressed very hard, bacterial and proteid turbidities may be effectively treated, whereas starchy turbidity, owing to the minuteness of the particles in suspension, cannot be removed by filtration.

The advantages of filtration are:

1. Greater brilliancy and consequent greater durability of the beer.
2. Saving in chips and isinglass, as well as the time, labor and utensils employed during that stage.
3. Doing away with beer remnants and their treatment, as a filter will allow the last residue of beer to be clarified and used.

The filter is inserted between the chip cask and the racking bench, the beer in its flow from the former to the latter being forced through the same.

FILTERING OPERATIONS.

Beer should always pass through the filter under back pressure, as it will otherwise foam to such an extent as to preclude the proper filling of the trade packages.

In cases where there is no back pressure racking apparatus, it is advisable to place the racking bench higher than the filter and chip-cask in order to produce a natural back pressure action, and prevent foaming. For the same reason, and in order to get a uniform flow of the beer to be racked, the hose connecting the filter with the racking bench ought to be at least 50 to 100 feet long, and handled so as not to form any sharp corners. The hose may be of one to one and one-half inch diameter, according to the size of the filter and the racking capacity desired. By increasing the size of the hose the racking capacity may be increased considerably.

The filter ought to be put in a cool place and if practicable, in the chip cellar. Several pounds' pressure is necessary for the passage of the beer through the filter to the racking bench. The pressure from the chip-cask is regulated according to the flow desired, and is limited by the degree of air-tightness of the casks and their soundness, and may reach 10 to 20 pounds. During the time when the filter is not in use it ought to be filled with cold, pure, iron-free water, preferably condensed or boiled water.

After the connection between the chip-cask, filter and racking bench is established, and the valve of the chip-cask is opened, water is allowed to escape till beer appears, and the operation of filtering properly started. A little foaming invariably takes place at the start, and the foaming liquid is let off till the beer begins to flow clear. Where the hose leading from the chip-cask is connected with the filter an observation glass will do good service, which should be supplied with an automatic appliance for closing the filter inlet as soon as the cask is emptied and air gets access to the flowing beer. This is usually effected by a rubber ball floating in the liquid in the glass cylinder, and settling in the outlet as soon as the liquid is displaced by air.

Racking into barrels at the bench is started as soon as the beer begins to flow clear. Care should be taken not to interrupt the flow of the beer as the filtering material would otherwise give off some of the retained particles and cause turbidity for a few minutes.

OBSTINATE TURBIDITIES.

It happens, occasionally, that turbidities will not yield to the ordinary treatment, and special treatment then becomes necessary, which should be governed by the nature of the turbidity. In all cases of obstinate turbidity an energetic chip-cask fermentation, obtained by using more Kräusen or sugar—or glucose—Kräusen will be found effectual. At the same time the filter mass should receive an admixture of fine asbestos fiber, and be packed tighter to make it more effective. In this way wild yeast, bacteria and proteid turbidities are practically removed.

STARCH TURBIDITY.

When kräusening the beer, add one quart of cold extract of malt ("Kalter satz") to 50 barrels of beer.

To prepare this cold extract of malt: To 20 pounds of crushed malt add 10 gallons of cold water, stir well for 10 minutes, allow to settle for one-half hour, pour off the liquid through a flannel cloth, bring the thick malt upon the flannel, and allow to drain. Of the liquid so obtained add one quart to 50 barrels of beer, preferably when kräusening.

PROTEID TURBIDITY.

This form of turbidity often disappears upon warming the beer slightly, so that it often happens that it is cloudy in the cellar and has become entirely brilliant, when tapping in the saloon.

If the beer is very cloudy, sugar Kräusen should be used for treating it (see Preparation of Bottle Beer).

Beers showing proteid turbidity should never be used for pasteurized bottle beer.

ABNORMAL TASTE AND ODOR OF BEER.

There are times when notwithstanding all precautions have been properly taken—at least the brewer so thinks—the finished beer will possess an abnormal taste or odor, making it unsalable or at least less palatable. In such cases the important thing to do is to go over the whole course of manufacture in the most searching manner, to discover at what point a mistake was made, and take measures to forestall any repetition of the calamity.

For the immediate purpose of saving the imperfect beer and making it as sound as possible, prompt and drastic measures are required. Wherever possible, natural means should be employed, and the use of chemicals avoided, and in most cases it will be found that sugar, hops, a hopped sugar solution or more or less Kräusen, more strongly or more weakly hopped, as the case may warrant, will prove effective, will cure the evil by returning, as it were, to an earlier stage and going through the various processes once more, with an eye single to the removal of the existing evils.

Among the tastes and odors of most frequent occurrence, representing deviations from the desired properties of the beer, the following may be mentioned:

BITTER TASTE.

This may be caused by the use of too much hops, especially Western or Pacific Coast hops, which are frequently found to give beer a rank, bitter after-taste if used in large quantities. Not more than half of the hops used should consist of Pacific Coast hops if the amount used is over one pound per barrel. Blending hops grown in different localities will be found productive of good results.

Other causes that may lead to an unpleasant bitter taste are, (2) boiling the hops too long; (3) leaving the wort standing too long in the hop-jack, or (4) the presence of wild yeast.

Treatment: The beer in the chip-cask should be treated with more than the usual amount of Kräusen, less strongly hopped.

SWEET TASTE.

An excess of sweetness, or too mild a taste, may be caused by too much sugar, or an insufficient amount of hops.

Treatment: The beer in chip-cask should be treated with less Kräusen, strongly hopped.

HARD OR TART TASTE.

This is caused by too much acid, usually lactic acid; such beers are also difficult of clarification.

Treatment: The beer should receive an addition of soda—not bicarbonate of soda, as this will make the beer foam too much—to neutralize the acid. The amount to be added depends on the degree of acidity. In some localities the addition of soda to the beer is a general practice in order to give the beer a milder taste.

ONION TASTE.

This is due to a peculiar condition of the yeast, some varieties giving rise to it more quickly than others. The yeast may at the same time be entirely pure. Change your yeast at once, as soon as this taste or smell becomes noticeable.

CELLAR TASTE.

Beers will readily take up any foreign odor, as when in contact with wood or pitch, poor varnish, or when the cellar air has a rotten or foreign odor like that of asphalt from a freshly laid floor, or tar from tar-paper used as an insulating material between the walls. Beer should, therefore, be carefully protected from contact with any such odor either in a vessel or in the air. A brewer should also avoid the employment of any substance in the cellars that has a foreign odor, for instance, substances for disinfecting or for cleaning purposes like carbolic acid and chloride of lime.

STABILITY OF BEER.

A beer which is expected to possess durability should have as few particles as possible in suspension. It should be perfectly brilliant.

A distinction should be made between:

1. Stability of pasteurized bottle beer (export bottle beer).
2. Stability of not pasteurized beer (export draught or local bottle beer).

If pasteurized beer becomes turbid, it is usually proteid turbidity, otherwise the beers have not been properly pasteurized. (See "Bottling Department.")

If keg beer or not pasteurized bottle beer becomes turbid, it is usually yeast turbidity.

If beer kept for a certain time shows any other turbidity outside of these two characteristic turbidities, it was not racked off in a sound condition, or it was infected by foreign organisms in keg or bottles due to improper cleaning of the same.

A sound beer filled into clean packages should not become sour or show a turbidity due to foreign organisms.

PASTEURIZATION OR STEAMING.

This is a process designed to give greater stability to beer. (See also "Bottling Department.") In general outline it consists in heating the finished beer in bottle to a temperature sufficient to kill such yeasts and other organisms as may remain in the liquid, excluding the light during this process, after which the beer is cooled.

The problem that presents itself in this treatment is to reach and hold a sufficient heat to accomplish the destruction of all germs without materially affecting the beer itself as to taste or brilliancy, or causing too much loss by breakage of bottles. Various devices have been constructed for steaming. No altogether satisfactory method of pasteurizing beer in kegs or casks or otherwise in bulk has yet found its way into brewery operations.

SPECIAL AMERICAN BOTTOM FERMENTATION BEERS.

EXPORT BOTTLE BEER.

At every step from the purchasing of the barley to the proper putting up into packages and storage, of the pasteurized beer, all precautions should be directed toward getting rid of the proteids. (See "Principles of Brewing.")

In a general way, superior material must be used for bottle beer to what is necessary for keg beer, or any brand designed for immediate consumption. The reason is that bottle beer is calculated to be kept longer and under more trying conditions, going quite commonly into residences or otherwise into private use where there are none of the facilities for giving beer appropriate treatment, such as a well appointed bar-room possesses. The adverse influences to which beer is exposed in transit during long journeys also count in this connection.

DIRECTIONS FOR PREPARING PALE OR EXTRA PALE BOTTLE BEER.

Materials: Take only a choice pale malt, well grown, i. e., about 90 per cent of the kernels should have the acrospire developed to three-quarters or the whole length of the kernel, and the barley should contain only a limited number of glassy and half-glassy kernels. The malt should have been stored for three months, having been carefully treated in the dry-kiln by preliminary drying on the upper floor at a low temperature, i. e., not to exceed 100° F. (30° R.), and thorough airing during this process, followed by a final temperature on the lower floor of not less than 167° F. (60° R.). (See "Kilning Operations.")

Use only best quality of rice free from any musty smell and free from foreign seeds, or best quality of grits or flakes containing not more than 1 per cent of oil, nor more than 13 per cent of moisture, or corn starch.

For methods of mashing and boiling see "Mashing and Boiling Operations."

Fermentation: The wort is pitched with 1¼ pound of yeast per barrel at 45.5° F. (6° R.) and temperature allowed to rise to 59° F. (8½° R.), then cooled to 39° F. (3° R.).

The storage cellar should be kept as near to freezing point as possible, the chip cellar between 34° and 36° F. (1 to 2° R.).

Storage.—The beer should be stored for three months.

Chip Cellar.—Treat the beer in the chip cellar as usual, but with the exception that sugar Kräusen should be employed instead of common Kräusen. The Kräusen should be prepared and used according to the following method, viz.:

Sugar Kräusen.—In 20 barrels of boiling water in hop, or rice-kettle, dissolve 600 pounds of anhydrous grape sugar, boil for 15 minutes, add 30 pounds of fine American or imported hops, boil for 15 minutes more, run into hop-jack, cool to 55° F. (10° R.), add two pounds of yeast per barrel and allow to come into Kräusen. (In about 24 hours a fine white foam will appear.)

Now add to the beer in the chip-cask 10 per cent of these hopped sugar Kräusen, or five barrels per 50 barrels of beer, allow to work out of the bung-hole for three days.

For treatment of beer in bottling department see that head.

EXPORT DRAUGHT AND UNSTEAMED BOTTLE BEER.

Where beer is intended to keep for some time without being steamed, as in the case of keg beer shipped out of town or unsteamed bottle beer, certain points require particular attention:

1. The beer should be perfectly brilliant when racked off into the trade package; especially should it contain the least possible number of yeast cells and bacteria.
2. The beer should contain a proper amount of alcohol and as little sugar as possible.
3. It should be stored at a low temperature.

The less alcohol the beer contains when racked, the more sugar the beer contains when racked, the more yeast cells it contains when racked, and the higher the storage temperature after racking—the sooner it will become turbid and form a sediment.

An export draught beer should contain approximately 4 per cent of alcohol.

In order to reduce the amount of sugar to the lowest possible point:

a. The temperature of the principal fermentation should be allowed to rise to 51° F. (8.5° R.).
b. The beer should be stored for at least six weeks.
c. Kräusen with the smallest amount possible—about 10 per cent. Sugar Kräusen should not be used.
d. Let the beer work out of the bung-hole for 10 days, filling up with fresh Kräusen every day or two. Then fine and keep under five pounds' pressure for four weeks at least before racking.
e. Keep the chip cask cellar at a higher temperature than the Ruh cellar, viz., at 36½-39° F. (2-3° R.).
f. Use warmer Kräusen—51° F. (8½° R.)—i. e., pitch the Kräusen brew at a higher temperature, 49° F. (7½° R.). Preferably add to the beer about 5 per cent of Kräusen and carbonate it.
g. More chips should be used and the beer fined with more isinglass than usual, and it should then be filtered.

MALT TONICS.

These beers are made of a dark color, some having the general characteristics of a heavy-brewed Bavarian beer, like Kulmbacher, for instance, with a pronounced malt flavor and sweetish taste, a high percentage of alcohol and relatively small percentage of extract; others having the same general characteristics but a low percentage of alcohol and high percentage of extract. The latter type is brewed and fermented like the former, but receives a larger percentage of Kräusen, or wort, in the chip-cask.

Malt tonics are generally put up in bottles, attractively labeled and usually distributed by druggists. If such tonics are advertised for use for medicinal purposes and so sold by the retailer in good faith, and not as beverages, and if they really are medicinal preparations, the druggist will not require the United States retail liquor dealer's license to sell the articles. The mere addition of a drug used for medicinal purposes is not sufficient to exempt the dealer. As to such licenses as he may require under state or municipal laws and ordinances, local regulations must be consulted. (See "Legal Relations.")

Materials: High-dried malt with caramel malt, black malt or roasted corn, in quantities to suit color. hops from 1¼ to 2 pounds per barrel, according to flavor and degree of bitterness desired.

Strength of Wort: 16 to 18 per cent Balling.

Method of Mashing and Boiling. (See "Pure Malt Beer.")

Method of Fermentation and Storage. (See "Bottle Beers.")

Treatment in Chip-cask: Use from 15 to 30 per cent of Kräusen, and if low percentage of alcohol and high percentage of extract is desired, add in chip-cask a corresponding amount of wort.

Treatment in Bottling. (See "Bottling Department.")

TEMPERANCE BEER.

By this term certain beverages are known which are intended to be sold in districts where the sale of intoxicating liquors is prohibited. The percentage of alcohol is reduced so as to make the beverage non-intoxicating. (See "Legal Relations.") Such beers are usually produced from a wort of 6 to 8 per cent Balling, containing no more than 4 per cent of reducing sugars.

Materials: Pale malt with or without unmalted cereals or sugars.

Mashing Method: Wahl's Lauter-mash method will give good results (see "Mashing Operations") where a brew is specially made; otherwise the spargings of an ordinary brew may be used together with glucose containing a high percentage of dextrin. Add one-half to three-quarters pound of hops per barrel in kettle.

Fermentation: Add three-quarters pound yeast per barrel at 45° F. (6° R.), let rise to 48° F. (7° R.), cool to 39° F. (3° R.), store one week.

Treatment in Chip Cellar: Kräusen with 15 per cent of temperance Kräusen and treat beer as usual or carbonate.

Treatment in Bottling. (See "Bottling Department.")

CALIFORNIA STEAM BEER.

This beer is largely consumed throughout the state of California. It is called steam beer on account of its high effervescing properties and the amount of pressure ("steam") it has in the packages. The pressure ranges from 40 to 70 pounds in each trade package, according to the amount of Kräusen added, temperatures, and time it takes before being consumed and the distance it travels from saloon rack to faucet, etc. Usually 50 to 60 pounds' pressure is sufficient for general use.

Strength of Wort: 11 to 12½ Balling.

Materials: Malt alone, malt and grits, or raw cereals of any kind, and sugars, especially glucose, employed in the kettle to the extent of 33⅓ per cent. The barley is malted as for lager beers. Roasted malt or sugar coloring is used to give the favorite amber color of Munich beer.

Mashing methods vary greatly. Some brewers employ English mashing methods, but the double mashing methods employed in a great many lager beer breweries, starting with low temperatures, in fact, mashing as though for lager beer with the exception of stopping and mashing at 158° F. (56° R.) until all is converted, will give very good results. But as a rule the initial temperatures are taken about 140° to 145° F. (48° to 50° R.), then to 149° to 154° F. (52° to 53° R.), mash 10 to 15 minutes, and then raise to 158° F. (56° R.) as final temperature.

The raw cereals are cooked and added in the same manner as if conducting a lager beer mash.

The mash is allowed to rest about 45 minutes, and the same precautions taken in running off wort and sparging as in other mashes, the sparging water to be about 167° F. (60° R.).

The hops used depend upon the quality. Of a good quality, three-fourths of a pound per barrel is used and added in the usual way.

The wort is boiled as soon as the bottom of the kettle is covered, and after the kettle is filled, boiling is continued for one to two hours. The wort is then pumped to the surface cooler, and then over the Baudelot cooler and cooled to about 60° to 62° F. (12° to 13° R.). In breweries where no cooling apparatus is used, the wort is exposed over night, or until it is cooled to about the above temperature.

Fermentation: The wort is now run into tubs of the starting tub style and size, where it is pitched with about one pound per barrel of a special type of bottom fermenting yeast, and well aerated. In about 14 hours a thick, heavy Kräusen head appears from which the beer to be racked off is Kräusened. The temperature of the beer is now about 2° to 3° F. higher, or about 62° to 63° F. (13° to 14° R.) if pitched at 60°. After

Kräusen have been taken it is run into long, wide shallow vats, called clarifiers, which are made of wood, about 12 inches high. Precautions should be taken that clarifiers, in which the beer stands six to eight inches high, are not too cold, so as to give the wort running out of the tubs a sudden set-back which may check fermentation. This can easily be avoided by sprinkling the clarifiers with hot water previous to letting wort run.

The wort then ferments in the clarifiers for two to four days. Precautions are taken against exposure to sunlight, and the fermentation should not rise too high. The matter which rises to the top is skimmed off continually.

When indications are the same as in lager beers, viz., dark color, yeast well settled, good, clear break, etc., it is ready to be racked directly into trade packages, or if for some reason it is deemed expedient, it may be racked into small casks of 5, 10, 15 or 20 barrels' capacity and kept there at a moderate temperature until wanted, then Kräusened and racked off. If racked off directly from clarifiers, the Kräusen is added with a quart measure to the trade packages, according to the amount of carbonic acid desired, the weather, etc., usually about five gallons per one general trade package called one-half barrel or 15 gallons, or, in general, about 33 to 40 per cent.

Finings are also added to each keg in about the same proportion as for lager beer. Trade packages are then gone over with a special filling can, filled completely and closed with iron screw bungs, when after two days it is ready for shipment. It should, as a rule, be about 5 or 10 days old before leaving the brewery, when it has attained the necessary pressure. In the saloon it is laid up for two days to allow settling, the bung being opened, as a rule, over night, to allow just a small amount of gas to escape, so as to be able to draw from the faucets without getting too much foam. This is done if drawing directly from keg, while, if using beer apparatus, "steaming," as the escape of the gas is termed, is unnecessary.

If this beer is properly brewed and handled it makes a very clear, refreshing drink, much consumed by the laboring classes. It will keep for some time in trade packages, i. e., from 2 to 6 months, but is usually brewed and consumed within a month or three weeks

PENNSYLVANIA "SWANKEY."

This beer has a local reputation in some parts of Pennsylvania, and is still brewed in Allegheny. It may also be classed as a temperance beverage, containing but little alcohol. Its name is probably a corruption of the German "Schwenke."

The material employed is malt. Balling of wort, about 7 per cent, hops about one-half pound per barrel, and a flavoring condiment like anise seed.

The malt is doughed-in at 167° F. (60° R.), and the mash held at 154° F. (53½° R.) until inverted.

The hops are boiled one to two hours, the condiment about 30 minutes.

The pitching temperature is about 61° to 63° F. (12° to 14° R.). The beer is run into puncheons as soon as the Kräusen begin to fall, is allowed to spurge out, and is topped up every few hours, until the Balling of beer is about 5, when the beer is racked into trade packages and stored at about 61° to 63° F. (12° to 14° R.), until it has raised sufficient life, when the beer is cooled to about 42° to 45° F. (5° to 6° R.) and marketed.

Cream, Lively or Present Use Ale, Still or Sparkling Ale, American Stout, Porter and Stock Ales, American Weiss Beer, Kentucky Common Beer, will be found under "American Top Fermentation Beers."

PRODUCTION OF THICK MASH BEERS IN GERMANY AND AUSTRIA.

The data on this subject were mainly taken from Thausing's "Malzbereitung und Bierfabrikation," 1898.

PROPERTIES OF THICK MASH BEERS.

(See also "Malting in Germany.")

Bavarian beer is light-brown (like the Munich) to dark-brown (like the Kulmbacher). It has palate-fulness, a sweet taste and malt flavor. Balling of wort about 12.5 to 14.5, Export and Bock about 15 to 18. On account of the pronounced malt taste the beer should be but lightly hopped.

Bohemian beer (like the Pilsener) is light-yellow to greenish-yellow; the taste is vinous, dry, somewhat sharp; instead of the malt taste, the bitter taste of hops predominates. The light Bohemian "Abzug," or "Schenk" beers are brewed 10.5 to 11.5 Balling, and are racked either in a clear condition or kräusened (Hefenbier). The lager beers, usually from worts of 12.5 per cent, are as a rule not kräusened.

Wiener beer as to taste, amount of hops and color takes a middle place between the other two.

The lager beer is brewed 13.5 Balling, the "Abzug" beer, which is racked soon after fermented, about 10.5. Wiener "Märzen" and export beers about 14.5 to 15.5 Balling.

THE DECOCTION OR THICK MASH METHOD.

According to Thausing modern beer in Germany and Austria is brewed according to the decoction method with three mashes, while formerly three different systems were distinguished and known as the Vienna, the Bavarian and the Bohemian. This distinction has become obsolete, since at present in Austria, especially in Vienna, as well as in Bohemia and Germany the decoction method with three mashes is universally employed. Here

and there slight changes are made in certain breweries in regard to the temperature periods and the time of boiling the mash without, however, any perceptible differences in results as to the character of the beer.

The initial or doughing-in temperature is about 28° to 30° R. (95° to 100° F.). If hot water is run in, it should be done slowly and while keeping the mashing machine moving, so that this proceeding will take 15 to 20 minutes.

Three parts of the whole mash are successively boiled and called the first, second and third mash, each for 10 to 45 minutes. In Bohemia, where pale beers are the vogue, boiling is often restricted to 10, 15 or 20 minutes, in Vienna generally 30 minutes, in Bavaria often 45 minutes.

As to heating the mash in the kettle, experience shows that this should not be done too quickly, but that on the other hand, it is not only a waste of time, but also may impair the quality of the beer, if the mash is left for a prolonged period at low temperature, i. e., heating it too slowly. This heating is governed to a certain extent by the qualities of the malt. The method of heating is most important with the first mash, which, in the three-mash process, is run into the mash kettle at a temperature of 28° to 30° R. (95° to 100° F.), and there frequently raised to 40° to 45° R. (122° to 133° F.) by the remaining water.

This thick mash is then raised in 20 to 30 minutes to 60° R. (167° F.) and in 10 to 15 minutes more to a boil. To prevent scorching, the stirrers must be kept going until boiling begins. Where imperfect stirring devices are in use the temperature is not uniform throughout the mash, but higher at the bottom and near the sides than is indicated by the thermometer in the mash.

Enough of the thick mash was run into the pan to bring the total mash in the mash tun (first mash) to 40° to 42° R. (122° to 126.5° F.) by pumping it over. The mash should be pumped neither too fast nor too slowly. What is said about heating the mash applies here as well. About 15 minutes may be taken for this work.

The mash having been well worked through, a sufficient quantity is again run into the mash kettle so as to bring, upon return, the total (second) mash to 50° to 52° R. (144.5° to 149° F.). Part of the first mash having remained in the pan the second mash generally has 50° to 55° R. (144.5° to 156° F.) at once upon reaching it and can be so heated that it comes to a boil in 15 to 25 minutes, according to the malt.

The first two mashes are thick mashes. By keeping the mash machine going while the mash runs into the pans, much of the thick part of the mash passes into the pans. Brewers formerly were particular to boil very thick mashes, thinking thereby to make the beer very full to the palate. The third mash is generally a "lauter" or thin mash. Before running it from the tun the mash is allowed to rest for a while, permitting the solid parts to settle to some extent, whereupon the mash is run off so as to get as much clear mash as possible into the kettle. Brewers used to put a strainer before the outlet and, in some brewhouses, to drain off the "lauter" mash through the false bottom. At present, the distinction between thick and "lauter" mashes is not often made, and frequently three thick mashes are purposely boiled.

The third mash is brought to a boil as quickly as possible, usually in about 15 minutes. The quantity is to be taken so that the main mash reaches 60° R. (167° F.) by pumping up the "lauter" mash from the pan. This last operation is called "final mashing." It is followed by pumping the mash into the strainer (Läuterbottich), where it is kept in motion for some time by crutches or stirring machine to enable the grains to settle uniformly.

The decrease of diastatic power in the decoction mashes according to Lintner is considerable. (Zeitschrift f. d. ges. Brauwesen, 1888, p. 317.) If this power at 28° R. is designated as 100, it was found to be 61.1 at 42° R., 26.8 at 49.8° R., and only 26.8 during the straining period.

The mash having been brought from the mash-tun to the strainer (Läuterbottich) is left to stand. Then the wort is strained and the grains sparged, using the same general precautions already described for the respective processes in the production of American lager beers.

The wort is generally boiled in the kettle until it shows a good "break," then one-half of the hops is added, and after one hour's boiling the second half, which is boiled for an hour to an hour and one-half more. Total length of boiling with hops, two to two and one-half hours. Sometimes one-half of the hops is added as soon as the wort boils, one-quarter after one hour, the last quarter one hour before running out.

According to Thausing (Malzbereitung u. Bierfabr., 1898, p. 609) the amount of hops used for the different types of beer is generally given per hectoliter (about 25 gals.) of wort, mentioning the saccharometer indication of the wort.

For Bavarian beer, to one hectoliter beer of 12.5 to 14.5 per cent, hops to the amount of 0.20, 0.28 to 0.30 kg. are used.

For Vienna beers the quantities of hops per hectoliter used are as follows (1 kilo = 2.2 pounds):

For 10.5 per cent sacch. indication......	0.20 — 0.22 — 0.26 kg.
For 11.5 per cent sacch. indication......	0.25 — 0.28 — 0.30 kg.
For 12.5 per cent sacch. indication......	0.30 — 0.33 — 0.36 kg.
For 13.5 per cent sacch. indication......	0.32 — 0.36 — 0.40 kg.
For 14.5 per cent sacch. indication......	0.38 — 0.40 — 0.42 kg.
For 15.5 per cent sacch. indication......	0.40 — 0.45 — 0.50 kg.

For Bohemian beer the quantities of hops per hectoliter are as follows:

For 10.5 per cent sacch. indication......	0.30 — 0.35 — 0.40 kg.
For 11.5 per cent sacch. indication......	0.35 — 0.40 — 0.43 kg.
For 12.5 per cent sacch. indication......	0.42 — 0.46 — 0.50 kg.
For 13.5 per cent sacch. indication......	0.45 — 0.48 — 0.55 kg.

The boiling of the wort in the kettle, as well as the mashing in the mash pan, is as a rule still accomplished by means of direct firing, but steam heating is more and more taking its place in breweries of modern construction, since brewers have become convinced that the claims as to superior quality of beer from fire-boiled worts rested on prejudice. The amount of coal needed in steam heating compared to fire heating for the boiling of mashes and wort is about two to three. The amount of steam, according to Thausing, needed for this work, based on actual tests, varied from 36 to 54 kg. per hectoliter wort, which, based on an evaporating effect of 7.5 kg. would mean 4.8 to 7.2 kg. of coal per hectoliter, or about 13 to 20 pounds per American barrel, which figure is to be increased by 50 per cent in case of heating by direct fire.

In cooling the wort the same methods are employed and the same precautions are to be observed as in the corresponding operations in America (which see).

According to Prior, German worts contain in 100 parts of wort extract the following constituents, in approximate quantities:

Saccharose	2 to 6 per cent
Dextrose and levulose	6 to 9 per cent
Maltose	52 to 63 per cent
Dextrins	18 to 26 per cent
Gums (taken from the amount of gum obtained by Lintner from a Munich beer), about	0.18 per cent
Nitrogenous substances (N × 6.25)	3.13 to 5.6 per cent
Mineral substances, about	2 per cent
Free acids calculated as lactic acid	0.6 to 0.9 per cent

Aubry gives results of boiling hops with wort with regard to the amount of albuminoids eliminated. In 100 parts of wort extract he found the following amounts of nitrogen for unboiled wort and after boiling with hops (Wagner's Jahresberichte, 1892, p. 845):

		Total Nitrogen.	Nitrogen not precipitable by phosphoro-tungstic acid.	Amido Nitrogen
Unhopped wort	A	0.9263	0.5700	0.4053
	B	0.7915	0.5458	0.3845
	C	0.7653	0.5518	0.3967
Hopped wort	A	0.8921	0.7114	0.5943
	B	0.7576	0.4765	0.2964
	C	0.7416	0.5106	0.3881

Bungener and Fries obtained amounts of different albuminoids before and after boiling, as follows:

	Before boiling.	After boiling.
Total nitrogen	0.650 per cent	0.540 per cent
Albumen nitrogen	0.163 per cent	0.057 per cent
Peptone nitrogen	0.125 per cent	0.100 per cent
Amide nitrogen	0.362 per cent	0.383 per cent

PRACTICE OF FERMENTATION IN GERMANY.

According to Thausing, the pitching temperature is chosen lower for light colored beers and higher for dark colored ones, generally between 4° and 6° R. (41° and 45.5° F.). The maximum

temperature of fermentation for Bohemian beers is 6° to 7° R. (45.5° to 47.75° F.), for Vienna 7° to 7.5° R. (47.75° to 49° F.), for Bavarian 8° and 8.5° R. (50° to 51° F.). The amount of yeast used is the greater, the higher is the Balling indication of the wort, the smaller the fermenting vats, and the lower the temperature. The amount generally varies from one-third to three-fourths liter and should never be less than one-half liter for hectoliter of wort (about one pound per barrel).

The temperature of the beer after fermentation at the time when it is ripe for casking is 5° to 6° R. (43° to 45.5° F.). Sometimes it is cooled in the fermenting vats to 2° to 3° R. (36.5° to 38.75° F.). In the Munich breweries the beer is cooled on the way from the fermenting vat to the storage cellars, by means of pipe coolers to 3°, 2° or 1.5° R. (38.75°, 36.50° or 35° F.). The beer, ripe for casking, should contain a sufficient quantity of fermentable extract so that the secondary fermentation may proceed properly in the storage cellar. The opinion that high attenuated beers have a low degree of palate-fullness, and low attenuated beers a high degree thereof is untenable. If the beer in the fermenting cellar has high attenuation and shows sluggish after-fermentation a light bodied beer with poor foam-holding capacity is the result, whereas a high attenuation in the fermenting cellar combined with a proper secondary fermentation is unobjectionable. It is to be considered a favorable symptom if the difference between the attenuation of principal and secondary fermentation is a large one, and unfavorable if the difference is small. It will be unsatisfactory if this difference is only 2 to 5 per cent, satisfactory if 10 to 15 per cent, while differences of 20 per cent have been observed.

Some illustrations may be given:

1. A wort showing 10.5 per cent by the saccharometer reached 3.5 per cent by the saccharometer in the fermenting cellar, i. e., 66.6 apparent degree of attenuation ($v = 66.6$ per cent). After remaining in storage for six weeks the saccharometer still showed 3.2 per cent. The apparent degree of fermentation of the beer is calculated at 69.5 per cent ($v' = 69.5$ per cent). The difference between fermentation in fermenting and storage cellar ($v' - v$) is 2.9 per cent. The beer will turn out unsatisfactory.

2. A wort showing 13.5 per cent by the saccharometer is fermented in the fermenting cellar to 5.5 per cent ($v = 59.2$ per

cent); in the storage cellar after four months to 4 per cent by the saccharometer (v′ = 70 per cent). v′ — v = 10.8 per cent. The fermentation is normal.

3. A wort is fermented in the fermenting cellar from 10.5 per cent by the saccharometer to 3.5 per cent, and in the storage cellar to 2.5 per cent by the saccharometer. v = 66.6 per cent, v′ = 76.2 per cent; v′ — v = 9.6 per cent. Notwithstanding the high apparent attenuation in the fermenting cellar the beer may be faultless.

The degree of attenuation that is desirable is different for different types of beer. For Bavarian beers an apparent degree of fermentation of 50 per cent is sufficient, whereas for Vienna and Bohemian beers 55 to 60 per cent is desired. Beers with low original extract should not attenuate so highly as beers with a high original extract.

CHIP AND STORAGE CELLAR.

Bohemian and Wiener lager beer is treated quite similarly in storage. Both are run "lauter" from fermenter, not "green;" storage temperature should be low, after-fermentation slow The 12 per cent Bohemian lager beer is stored three to four months, the Wiener 13 per cent lager-beers, about four to five months; neither is kräusened; the Bohemian is bunged for a long period, the Wiener often is not bunged at all.

Wiener "Abzug" beer, for which cold storage is essential, is six to eight weeks old, and is racked after a short bunging period The Bohemian "Jungbier" is usually kräusened when racked into the trade packages and must consequently be allowed to settle before tapping.

Bavarian beer is not aged as much as the others as this would interfere with the sweet taste and palate-fulness. Bavarian beer is brought on the market after bunging about eight to fourteen days, about four to ten weeks old, the stronger beers being stored longer.

In piping beer the casks can never be filled to the bung-hole, owing to the foam. Hence, they must be filled up the following day. Sooner or later a white foam appears at the bung-hole, which proves an active secondary fermentation. The greener the beer was racked into cask, the more it contains of readily fermentable extract, and the warmer the beer and the storage cellar are kept, the bigger will be the hood of foam, and the after-fermentation may be so vigorous that beer is ejected from the bung-hole and runs down over the cask. This ought not to happen. In order to avoid loss of beer and for the sake of cleanliness, vessels are placed on the bung-holes to receive the foam and beer that is forced out, which is always very bitter. This is used for filling up casks or, properly treated, can be put on the market. The same object can be attained by not filling up the casks to the bung-hole until the intensity of secondary fermentation has somewhat abated. It is always advisable to let the foam work out of the bung-hole.

If no hood of foam rises from the bung-hole, notwithstanding the casks are full, or if it disappears very soon after rising, the beer being "dead" in the cask, it is a sign of deficient secondary fermentation which is always bad. The causes may be faulty malt, either overgrown or undergrown or spoiled in kiln, yielding a deficiency of fermentable extract in the beer; more rarely it may be due to casking the beer while too "lauter" (clear). The brewer should always watch the secondary fermentation closely.

The hood of foam contracts and takes on a deeper color, finally disappearing entirely, which is always the case with a sound beer if the cask was not full. The composition of the extract, the strength of the beer and the temperature of the cellar cause the foaming to stop sooner or later. What the brewer wants is that the hood remain for rather a long time without any violent working out. It affords a symptom for judging the progress of the secondary fermentation. After the hood has disappeared, the cask is filled up once more. For beers that are used young, stored cold, and properly prepared so as to be of normal composition, it ought to be enough to fill up once, as the secondary fermentation lasts a long time. Lager beers are generally filled up two or three times and when they have stopped throwing up foam, the bung-hole is loosely covered with the wooden bung.

CLARIFYING CHIPS.

While in storage, a sound beer becomes clearer by degrees, the particles making it turbid, as yeast and other suspended matters, especially albuminoids, settling on the bottom. In order to hasten clarification and make it perfect, clarifying chips are put into the beer where filters are not used.

These chips are made of hazel or white beechwood. The wood is cut so as to secure straight chips about 16 to 18 inches long, 1.5 to 2 inches wide, and $\frac{1}{16}$ to $\frac{1}{10}$ inch thick. They should be smooth and without cracks. Before using them they are thoroughly boiled in a special tub, changing the water repeatedly, steam that is pure and without oil or other impurities being commonly used, whereupon they are rinsed in cold water. They are wet when put into the storage cask, being inserted either into the empty cask through the manhole, which is simple and quick, or being added through the bunghole after the cask has been filled with beer. The beer is run on the chips if it is to be marketed soon, whereas it is preferable to insert the chips through the bunghole if the beer is to remain on storage for some time. They can be put in two to four weeks before racking for shipment, in the latter case. As to the number of chips for a cask a little experience will speedily give the requisite information. The more quickly the beer is to be clarified and the more stubborn it is of clarification the more chips should be used. As a rule one kilogram of wet chips is enough for one hectoliter of beer, which is equal to about half a kilogram of dry chips. Care should be taken to prevent chips lying in front of the tap-hole, which might cause trouble in racking. This is more likely to happen where the beer is run on the chips and for that reason experienced brewers generally prefer to put in the chips through the bung-hole or else remove the chips from the tap-hole after the cask has been filled.

"KRAEUSENING."

Occasionally the practice is met with of pumping beer intended for local consumption, from the storage cask to smaller casks, often on chips, and to "kräusen" it strongly at the same time, whereupon after it has become clear, it is bunged and racked, or, in small breweries, drawn directly for immediate consumption. It is believed to acquire particular brilliancy and life by this treatment.

Lager beers, and often young beers, are generally racked from the storage casks without "Kräusen" and quite clear. They are called "Abzugbier" in Austria. In Bohemia more especially, the practice prevails of adding some fermenting wort, in the low "Kräusen" stage, to clear young beer when racking into trade casks, particularly in the cold season. This wort is called "Kräusen" for short. The amount of "Kräusen" to be added should be the greater, the less active is the yeast, the older and more attenuated the beer, the more foam is desired, the warmer the storage cellar in the brewery and the colder the bar-room in which it is to be kept while being consumed. The amount of "Kräusen" should, therefore, be governed by the condition of the beer and yeast, and the season. If too much is added, there will be danger of the beer being turbid when tapped and perhaps not becoming clear again at all. A small amount of "Kräusen" is half a liter per hectoliter, a large amount is 5 to 6 liters. As a rule, 2 to 4 liters per hectoliter is enough. The amounts must be determined empirically in each brewery and varied to meet the requirements.

"Kräusen" should always be taken from normally fermenting worts.

"Kräusened" beer, before being drawn, should lie still in the place of consumption for some time, from one to eight weeks, according to the temperature of the place. It should also remain lying still while being drawn. Only in rare cases does the practice survive of the dispenser of the beer opening the cask, filling it up until it is clear, and bunging it once more. If this is done, plenty of "Kräusen" should be given, as much as 10 liters per hectoliter or still more.

"Kräusening" serves to revive active fermentation in the beer. It is made to foam strongly and the large amounts of carbonic acid developed imparts a sharp taste and the foam becomes firm. It enables even beers that have been stored warm and are not suitable for consumption, as "Abzug" beers, to be sold in good condition. This affords a reason why breweries which put out "kräusened" beer need not be so particular about keeping their cellars cold. The Bohemian breweries sell their young beer all through the year almost altogether with "Kräusen," only lager beer being marketed without "Kräusen." It is the practice at Pilsen to allow the beer after being racked into trade casks with "Kräusen," to lie in the brewery for several days and undergo another fermentation, filling them up again just before they leave the brewery. The beer thereby becomes ready for consumption in the dispenser's room in a shorter time, requiring less time of storage on that account, furthermore, being stored in a cold cellar will foam better, the foam will be more solid and lasting, and the beer taste more prickly, all of which are virtues that distinguish good Bohemian beer. Another advantage of "Kräusening" is that the fermenting beer in the trade cask is less sensitive to severe cold and also suffers less from heat. This is important in shipments to long distances, and explains why it is customary in Bohemia to add a small amount of "Kräusen" (one-half to one liter per hectoliter) even to lager beers which are intended for long distance shipments (export beers).

Beers that have been "kräusened" can be sold younger than "Abzug" beers, and need not be quite clear when leaving the brewery, since they remain in storage at the public-house where they become clear, provided the beer was good to begin with, the "Kräusen" is strong and the beer properly treated. This accounts for Bohemian breweries getting along with small storage capacity.

BUNGING.

The bunging period differs widely for one type of beer. General rules cannot be given. In Munich the summer beers are commonly bunged for about two weeks, the younger and weaker winter beers six to eight days. Vienna "Abzug" beers are usually bunged one or two weeks, lager beers either not at all or not to exceed two weeks. Bohemian lager beers are generally bunged for a long time, viz., up to four weeks and over, particularly if the storage cellars are moderately cold and the beers old. The pale Bohemian beer which is generally more highly fermented requires and stands longer bunging. The practical brewer will readily see if a beer has been bunged enough by drawing a sample through the try-cock. When the beer is agitated in the sample glass, numerous tiny bubbles of carbonic acid gas should rise in it slowly. It is a bad sign if the carbonic acid liberated by the agitation escapes quickly.

In draught (Abzug) and lager beers that are to be racked clear it is customary, in order to obtain the necessary life, to bung the casks tightly, thereby preventing the escape of carbonic acid gas and creating a pressure in the same.

The influence of temperature and bunging on the carbonic acid content of beer is shown by Langer and Schultze. The amount of carbonic acid in worts of 10 per cent B., in which 57 per cent of the extract was apparently fermented in the principal fermentation, was:

		Decrease of carbonic acid content per 1° C.
At 0.4° C.	= 0.332 per cent	= 0.010 per cent
At 1.6° C.	= 0.326 per cent	= 0.010 per cent
At 2.8° C.	= 0.311 per cent	= 0.008 per cent
At 4.0° C.	= 0.297 per cent	= 0.012 per cent
At 4.7° C.	= 0.297 per cent	= 0.017 per cent
	Average	= 0.012 per cent

It may be said that within the range of temperature from 0° to 5° C., the carbonic acid content of a Vienna "Abzug" beer, with equal pressure, rises or falls by about 0.01 per cent, according as its temperature rises or falls by 1° C.

The carbonic acid content of this Vienna "Abzug" beer when bunged for five and four days, respectively, showed an average increase for three tests of 0.046 per cent, i. e., 100 g. beer after bunging contains 0.046 g. carbonic acid more than before bunging, or 100 c.c. of beer by bunging takes up an additional 23.8 c.c. of carbonic acid. For 36 hectoliters of beer this amounts to nearly 9 hectoliters of carbonic acid gas more absorbed by bunging.

To increase the carbonic acid content of beer 0.01 per cent, an average excess of pressure of 31.3 mm. mercury column at 0° C. was required. When bunging was over, the tension within the cask averaged no more than 0.19 atmospheres.

The largest amount of carbonic acid that could be forced into this "Abzug" beer by the lowest cooling and moderate bunging at the same time was 0.390 per cent. The beer was excellent.

With 0.320 per cent of carbonic acid the "Abzug" beer of a brewery in Vienna was only medium good as to life and prickliness, but if the carbonic acid content fell below 0.320 per cent, the consumers began to complain.

SPECIAL GERMAN BEERS.

Besides the recognized types, like the *Bohemian*, *Vienna* and *Bavarian* beers, of each of which there are brewed two varieties, the *Schenk* or *Winter Beer* and the *Lager* or *Summer Beer* (see above), there are beers brewed for special purposes of each type like *Bohemian Export, Vienna Export or Bavarian Export,* or beers brewed for special occasions like *Bock*.

Export and *Bock* differ from the Schenk and lager in that they are brewed stronger and contain more alcohol. Thus the percentage of alcohol and extract found, as the result of the analyses of a large number of beers, was on the average:

	Alcohol.	Extract.
Schenk or Winter Beer	3.36	5.34
Lager or Summer Beer	3.93	5.79
Export Beer	4.40	6.38
Bock, Doppelt or Märzen	4.69	7.21

Beers are brewed in certain localities which have achieved a reputation far beyond the confines of their homes and which have certain peculiarities that distinguish them from the ordinary type. Such are:

Kulmbacher.—A very dark beer with the Bavarian characteristics especially accentuated, brewed along the lines of a Bavarian lager, from a very strong, original Balling of wort of about 18 to 19 per cent.

For Braunschweiger Mumme, Broyhan, Weissbeer, Adam beer and other special German beers, see "German Top-Fermentation Beers."

TOP FERMENTATION BEERS.

IN THE UNITED KINGDOM, AMERICA AND GERMANY.

While on the continent of Europe the lager or bottom-fermented beers have rapidly displaced the old-time top-fermented beers, excepting Weissbeer, they have been unable to gain much headway in the United Kingdom, where top-fermented beers, as ale and stouts, still hold undisputed sway. The same is true of Canada, and other English possessions, where lager beer breweries are still unknown in many localities, while in the United States there has been a decided revival of interest in ales especially.

ENGLISH TOP-FERMENTATION BEERS.

The beers brewed in the United Kingdom and its possessions show similar characteristic differences in their properties as the German beers. They are called "ale," "porter" and "stout."

Mild beers, whether ale, porter or stout, are called such as undergo no secondary fermentation, but are marketed about seven days after the principal fermentation is finished.

Stock beers, or old beers, whether ale or sout, are such as have undergone a secondary fermentation and are stored about two months or more before marketing.

The mild beers are distinguished from the stock beers by a more sweetish (mild) taste, containing more unfermented malto-dextrin and less acid, the old beers, on the other hand, becoming more alcoholic and tart. There is, therefore, much difference in the properties of mild beers and old or stock beers.

Mild ales are usually brewed of a darker color than old ales, with less original gravity and less hops.

Old or stock ales have a pale to amber color, quite bitter taste, more or less tart taste, strong hop flavor, and though brewed with a high percentage of extract, have less extract left, but contain more alcohol than stout, which is mainly due to the practice of dry-hopping ales, which results in breaking down the malto-dextrins more effectually than is the case with stout, which is not dry-hopped.

Stouts are quite dark, almost black, have a pronounced malt-caramel taste and aroma, a sweetish taste if mild, and a more or less tart taste, according to age and circumstances. They are brewed stronger than ales.

Porter is brewed less strong than the old beers. It stands in a similar relation to stout as does a mild ale to a stock ale.

BREWING MATERIALS IN ENGLAND.

The materials used in England, besides malt, hops and water, are usually sugars of different kinds. Such are caramel (produced from glucose) for black beers, invert sugar and glucose for mild and stock ales, while of late years, rice, maize and wheat are gaining in favor. The English drinking public now prefer beers of low gravity to the stock beers, and since they should contain only a moderate amount of alcohol, but sufficient extract to be full to the palate, sugars should be used for these beers, containing the requisite amount of unfermentable extract.

Malt.—Most brewers use some foreign barley malt, together with that produced from domestic grain, on account of the better clarification of beer and better drainage of wort, while some brewers use California barley malt entirely, the beer from which keeps better in hot weather (Thatcher Brewing and Malting, 1898, page 20). Foreign grain, besides, does not develop so much acidity and mold during germination.

Usually pale malt is employed in the production of all the beers, together with some coloring material, preferably caramel, brown malt, amber malt or roasted corn for dark ales, porter and stout. Sometimes black beers and mild ales receive an addition of caramel solution in the fermenting vessel just prior to the close of the principal fermentation. For dark beers higher kiln-dried malts are preferred by many brewers.

As to the requirements the malt is to meet and the production of English malt, see "Malting in England."

Hops.—With regard to hops, the English brewer favors the employment of foreign qualities of hops to blend with the domestic article, the proportion frequently rising to 50 per cent.

The English hops are distinguished for their delicacy of flavor, especially the East Kent goldings, and these are eagerly sought for flavoring choice pale ales in dry hopping.

The relative quantities of hops and of other materials to be used in brewing the different beers, according to the gravity of wort and other requirements, may be gathered from the subjoined table:

	Lbs. Hops in Kettle, Per Quarter Malt (336 Lbs.)	Gravity Long.	Hops in Kettle Per American Barrel.	Balling of Wort.
	Lbs		Lbs.	
London pale bitter ale....	8–10	20-21	1½–2	14
Burton mild ale............	7–8	19-21	1¼-1½	14
London four ale (mild)....	4–7	19–21	⅘–1¼	13–14
Burton strong ale..........	10–14	23–25	2–3	16–17
Burton pale ale............	12–15	23–25	2½–3	16–17
Burton export ale....	18–20	25–27	3½–4	17–18
Porter....................	4–8	18–22	⅘–1½	13–15
Single stout..............	8–10	23–27	1½–2	16–18
Double stout..............	10–12	27–30	2–2½	18–20
Imperial stout............	14–15	30–40	2½–3	20–25
Russian export............	16	above 40.	3¼	above 25

Water.—The water used in brewing is given much attention in England (see "English Brewing Waters" in chapter on "Brewing Materials").

BREWING SYSTEMS.

Mashing operations are carried out according to the infusion system, although semi-decoction, or limited decoction, is employed in some breweries, especially where unmalted cereals are employed.

The mash for the production of the various beers is varied somewhat according to the materials used and the type of beer to be produced. For ales brewed from pale malt, higher initial temperatures should be taken than for black beers, or stout, where high kiln-dried malt is employed, and where a high degree of stability is required, like Dublin stout; whereas for London stout brewed for rapid consumption, moderate initial temperatures may be used to advantage.

The amount of malt used to mix with the water is about 125 pounds per American barrel (2 English barrels per quarter of 336 pounds).

In all cases water of a comparatively high temperature (striking temperature) is run into the foremasher or outside masher, where it is well mixed with the malt, then falling into the mash-tun, which contains warm water enough to cover the false bottom. The rakes are run to get even initial or primary temperatures, the mash is allowed to stand a short time, when the temperature is raised by an underflow of water of about 180° under the false bottom or through an underlet, to the end temperature, which is generally but little above the initial temperature. Here the mash is allowed to stand or rest for about one and one-half to two hours, after which the wort is drained completely, and sparging is undertaken. The temperature of the first sparging water is usually taken higher, about 170°, for a few barrels, as the grains have cooled somewhat; then 160° to 165° is taken, which will bring the temperature of the mash to about 160°, which is the permissible limit. After reaching this temperature the remainder of the sparging water should be run on so as to have the mash gradually recede to 152°, which is approximately the tap heat that should be maintained through sparging operations.

Temperatures may be taken as follows for different types of beer:

Pale or Stock Ale.—Initial temperature, 151° to 152°; stand 15 to 30 minutes; raise temperature by underflow to 153°; stand one and one-half to two hours, and tap.

Irish Stout from high kiln-dried malt. Initial temperature, 143° to 145°; let stand, 15 minutes; and raise heat 152° by underflow of 180°.

London Stout from high kiln-dried malt. Initial temperature, 148° to 150°; let stand, 15 minutes, and raise to 152°, with underflow of 180°.

Limited Decoction.—This process seeks to combine the German decoction process with the English infusion method. The mash is carried out as usual, the mash-tun being, however, provided with a steam coil. After running off the first wort to the amount of half a barrel per quarter (1 U. S. barrel to 500 pounds of malt) into a separate vessel until required, steam is turned on, and the temperature of the mash raised to 212° F. (80° R.) where it is kept for about 15 minutes, when the temperature is reduced to about 160° F. (57° R.) by sparging with cold water

while stirring. Then, the wort which was held in reserve is returned, and the temperature brought to 160° F. (57° R.). The mash is left to rest for 20 to 30 minutes, and taps are set, and operations continued as usual.

When unmalted cereals in the form of grits are employed they may be treated according to methods familiar to American brewers. In England, it would seem, the maize cannot be sufficiently gelatinized by employing the methods there in vogue, the unmalted cereals not being subjected to high enough temperatures, nor sufficiently long. The raw cereal mash when considered properly gelatinized, is cooled to the usual striking temperatures of the water, and the malt is run in to get the ordinary initial temperature, and operations are continued as usual.

Boiling the Wort.—While running into the copper the wort is held at a sufficiently high temperature to destroy the diastase, and some brewers boil while the kettle is filling, others bring to ebullition as soon as filled. Hops are sometimes added as soon as the heating surface is covered, but it seems to be becoming the more usual practice to add the hops when boiling sets in, adding all the hops at once in the production of black beers and mild ales, while in the production of stock or pale ales a large proportion (⅔ to ¾) is added when boiling sets in, the remainder about 15 to 20 minutes before turning out, the wort being left gently to simmer after the addition of the second portion in order not to lose too much flavor.

Some brewers boil only one hour, others two and more, but two hours' boiling seems to be becoming the more general custom.

In many breweries the copper has not sufficient capacity to hold the entire brew. The wort is then boiled "at twice," or in "two lengths," or even at three times or in three lengths.

Sparging is kept up under these circumstances until the kettle is full, the taps are then closed and the wort is allowed to "stand on" until the first length is finished, or the second length is collected in an "underback," where it is kept hot until needed.

From the copper the wort is "turned out" into the hop-back, where it rests for about 20 minutes, and is pumped to the surface cooler, where it lies until the temperature is reduced to 130° to 140°. It is then passed over or through a pipe cooler to reduce the temperature to 58° to 60° F. (12° to 13° R.), and is then ready to receive its addition of yeast.

TOP-FERMENTATION APPLIANCES AND OPERATIONS.

The essential difference between top-fermentation and bottom-fermentation is in the behavior of the yeast, which rises to the top during top-fermentation, where it is either removed by suitable implements, by a process called "skimming," or is allowed to work out of an aperture at the top of the fermenting vessel, by a process called "cleansing." If the cleansing takes place in casks, the yeast working out through "swan necks" into a common trough, it is called "Burton union system;" if through openings (lips) in the top and edge of upright tanks, the tanks themselves being so placed as to form a trough for the yeast, it is called "Ponto system." Then there is a combination of the skimming and the cleansing systems in the "stone square system," the yeast working out through the top of a closed stone square, from where it is removed by skimming.

FERMENTING VESSELS.

These are now chiefly constructed of wood (oak or fir and also American cedar of late). Stone and slate have not given satisfaction, although still extensively used in some parts.

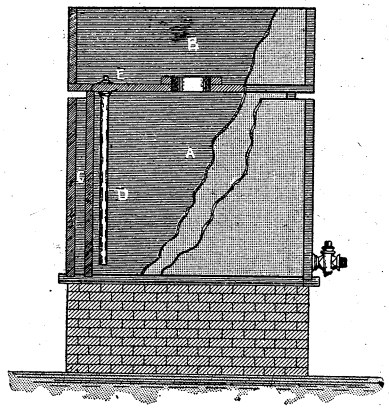
The vats are made either round or square and are called "rounds" or "squares," respectively. Rounds are usually made of oak staves, held together by iron hoops; squares, of planks about two inches thick, bolted together with iron bolts, generally made of fir or cedar.

The vessels are not coated with varnish or pitch, as is the case in lager beer breweries, as the alcohol in some ales reaches such a high percentage as to soften pitch or shellac. Oak vessels are prepared by filling them with boiling hot water a number of times, while fir containing much resin must receive special treatment. Southby recommends to fill such vessels first with boiling water, which is run off the next day. Then the sides are scrubbed with a mixture of 2½ pounds of chloride of lime per gallon of water. After 24 hours the vat is washed out with a mixture of one part of hydrochloric acid and four parts of water. Then it is washed out several times with boiling water and finally scrubbed out with an ordinary solution of bisulphite of lime to remove all traces of chlorine.

American cedar needs no special preparation, but may be used after being scrubbed out.

"Stone squares" should be constructed of large slabs of hard, impervious stone, or of slate, which retains a smoother surface during wear. The description and sketch here given are taken from Sykes, the Principles and Practice of Brewing, 1897, p. 445.

The stone square has a jacket, C, also built of stone slabs, leaving a space of about two inches, which is filled with water for the purpose of attemperating the beer. The square proper, A, is covered over with another slab having a circular aperture, the "manhole," of 18 inches' diameter, which is surrounded with a stone ring some 5 or 6 inches high, on which fits

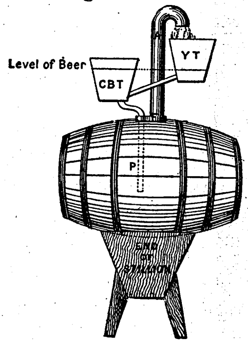


Yorkshire Stone Square.

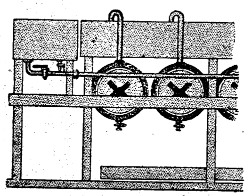
a stone lid provided with a handle. In one of the corners of the covering slab is another opening situated a few inches from each of the sides and about three inches in diameter, provided with a brass valve, E, to which a chain is attached. From the under side of the valve a tube, D, extends to within a few inches of the bottom of the square; this is technically known as the "organ pipe." Upon the upper side of the covering slab is placed the yeast trough, B, constructed of four stone slabs. It has the same superficial area as the square, and a depth of from 24 to 30 inches. A pump is one of the necessary adjuncts of a stone square. Its diameter is about three inches and stroke six inches. The stone square must be carefully cemented in all its joints and should be inspected from time to time, as any defects in the jointing are certain to make trouble.

Instead of the water-jacket an ordinary attemperator may be used inside. Slate cannot be cleansed by boiling water, as it would be likely to crack or split. Neither can bisulphite of lime be applied, as it would attack the slate. Neutral sulphite of lime is therefore used to whitewash the inside of the square for antiseptic purposes, while coatings or deposits on the surface are removed by caustic potash or soda solutions.

Loose Pieces.—Where the cleansing method is employed, brewers often run the beer from the square or round into casks or puncheons holding about four barrels. They are placed on troughs in which the yeast is collected that escapes from the bunghole. The casks are inclined to one side so



Cleansing in Loose Pieces—From A Handy Book for Brewers, by H. E. Wright.



Burton Union—From Sykes, Principles and Practice of Brewing.

that the yeast runs down one side only. Sometimes conical tinned pipes are inserted into the bunghole, called "swan necks," through which the yeast works out into the trough. The casks must be kept "topped up" continually—every two hours during the first 24—using for this purpose first the clear trough beer, and when this is used up, bright beer from a previous brewing.

The loose-piece swan necks are often so arranged that the same trough serves both as yeast receiver and feed trough (for topping up). But according to Wright it is much better to have them quite distinct, the only necessary precaution being to have the bottom of the feed trough some inches above the bung-

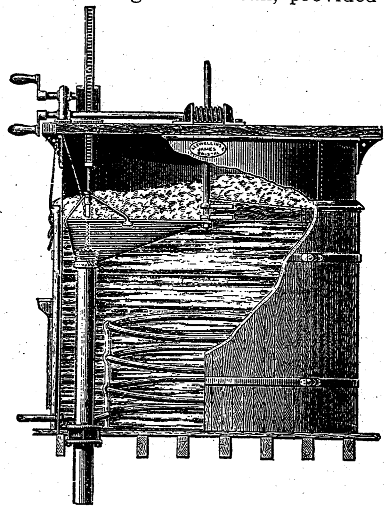
holes, so that the beer level may be well up the swan neck pipe (see sketch, page 800).

Burton Unions.—In this system the principle is the same as with the "loose pieces," but there are many differences in detail. The casks holding about four barrels are permanently mounted on tall wooden stands, to which they are slung by means of two axles, one attached to each head. These work in bearings and permit the cask to be rotated on its axis, the front trunnion having a square head upon which a handle fits for this purpose. The bunghole of each cask is provided with a conical brass socket, into which fits a hollow brass plug, carrying the swan neck to convey away the yeast. This is carried up vertically a foot and a half or two feet, makes a turn of half a circle and curves over into a long wooden trough which extends between the rows of adjacent casks, called the yeast trough. At one end of this another vessel is fixed, called the "feed trough," which has a capacity of five or six barrels. A tap is fixed into the bottom of this, from which a pipe of about two inches diameter proceeds, extending in front of each row of unions and giving off a short branch to each cask, with which it can be connected by means of a union joint to a tap permanently fixed in the head of the cask. Another cock is fixed in each cask exactly opposite the bunghole, and is provided with a short tube, which projects some little distance inside the cask, and which can be raised or lowered by means of a screw. This serves for the removal of the fermented beer, and as the tube communicating with the tap is some little height above the bottom, it serves to hold back the bottoms. When a set of unions are cleansed, the swan necks are first removed and the feed-pipe communications unscrewed; the handle is then attached to each cask in turn, boiling water poured into it and the cask rotated on its axis. This is an objectionable feature in the system, for the introduction of large quantities of hot water into the fermenting room necessarily raises its temperature. (Sykes, the Principles and Practice of Brewing, 1897, p. 448.)

Attemperators are made either fixed or movable. The fixed are made of tinned copper pipe, oval in section, and the whole forms a continuous coil circling the tun about three times.

Movable attemperators are suspended with chains and balance weights.

Arrangements for Skimming.—Small rounds or squares are usually skimmed by hand. In large rounds either a "parachute" or "skimming" board is used. The parachute is a funnel connected with a pipe penetrating the bottom of the tun. For rounds, the skimming board is made to revolve around a central rod, and is capable of being raised and lowered, as well as rotated, from the outside of the tun. It pushes the yeast before it into a trough, which extends (instead of a parachute) from the center to the edge of the tun, provided like the para-



Fermenting Round with Parachute—From Sykes, Principles and Practice of Brewing.

chute with a down pipe through the bottom of the tun. (Wright, a Handy Book for Brewers, 1897, p. 498.)

In the squares the trough extends along one of the sides.

A Rotary Pump is used for rousing and is so constructed that it permits of the raising of the continuous stream of wort, or pumping air into the fermenting wort.

Another contrivance for rousing and aerating at the same time consists of a small cask of about three gallons' capacity, with both its ends removed and having a number of holes bored through its sides. It is weighted with lead so as to sink readily, and suspended by a rope passing over a pulley. The

cask is let down into the fermenting wort and pulled suddenly to a short distance above its surface; by repeating this several times, a very efficient rousing and aeration is secured. (Sykes, the Principles and Practice of Brewing, 1897, p. 451.)

TOP-FERMENTATION OPERATIONS.

The amount of yeast to be added is dependent upon the system of fermentation used, the fermentation temperatures, gravity of worts fermented, materials and temperatures used to produce wort, quality and consistency of barm employed, and amount of aeration.

With the Yorkshire stone square system, a slow type of yeast is employed at the rate of only ¾ to 1¼ pounds per barrel.

The following table for the other systems may be found useful (Thatcher, Brewing and Malting Practically Considered, 1898, page 86):

AMOUNTS OF PITCHING YEAST REQUIRED FOR WORTS OF DIFFERENT GRAVITIES.

12 lb. worts	½ to 1 lb. per bbl.	or	⅓ to ¾ lb. per American bbl.	of	8¼ Ball.
15 lb. worts	1 to 1¼ lb. per bbl.	or	¾ to 1 lb per American bbl.	of	10¼ Ball.
18 lb. worts	1¼ to 1¾ lb. per bbl.	or	1 to 1¼ lb. per American bbl.	of	12¼ Ball.
21 lb. worts	1½ to 2 lb. per bbl.	or	1¼ to 1½ lb. per American bbl.	of	14¼ Ball.
24 lb. worts	1¾ to 2¼ lb. per bbl.	or	1½ to 1¾ lb. per American bbl.	of	16¼ Ball.
28 lb. worts	2 to 2½ lb. per bbl.	or	1¾ to 2 lb. per American bbl.	of	18¼ Ball.
30 lb. worts	3 to 3½ lb. per bbl.	or	2 to 2½ lb. per American bbl	of	20¼ Ball.
35 lb worts	3½ to 4½ lb. per bbl.	or	2½ to 3 lb. per American bbl.	of	23¼ Ball.

In many breweries the yeast is added to the whole of the wort after it has reached the fermenting tun. Sykes recommends first to run down a small portion of the wort at a temperature of from 65° to 75° F., and to mix the yeast with this. In this way a rapid and vigorous growth of yeast is secured from the onset, and the reproduction of any bacterial organisms, should these happen to be present, effectually held in check. The remainder of the wort is then run in at a slightly lower temperature than that which the whole bulk is to have when collected, so that at the finish the gyle may be at the proper heat. The wort, while being collected, is roused at frequent intervals in order that the yeast may be evenly diffused through it.

Where much rousing and aeration takes place the yeast will multiply faster, and less yeast is required for pitching (stone square system).

The best yeasts come from beers of medium gravity, not too heavily hopped. In strong worts the yeast gradually becomes sluggish, and in heavily hopped wort its surface acquires a coating of hop-resin, which naturally interfers with the fulfilment of its proper functions (Sykes).

Fermentation Temperatures.—The weaker beers of about 18 to 20 pounds Long. (12½ to 14½ Balling) are started at about 58° to 60° F., and are allowed to rise to 66° to 70° F. Stronger beers are started from 56° to 58° F., and are allowed to go up to 75°.

Where the plant is provided with powerful attemperators the fermentation may be commenced at a higher temperature and confined within narrower limits, say between 62° and 65° F., with good results. Lower fermentation temperatures are said to give beers with finer flavor.

Appearance of the Heads of Yeast During Fermentation (according to Sykes).—Two or three hours after pitching small bubbles of carbonic acid begin to rise to the surface. In another two or three hours froth begins to form around the sides of the vessel, and this gradually extends over the whole surface and increases in volume, until what is termed the "cauliflower stage" is reached. This then gradually passes into the "rocky head stage." The heads go on steadily increasing for a time, and often attain a height of three and four feet above the surface of the wort. The more or less "frothy head" now commences to fall, and the "yeasty head" commences to form. This is in a constant state of motion from the continual formation and bursting of the large bubbles of gas. With the commencement of the formation of the yeasty head, what is known as the "skimming point" is reached, the normal time for this being about 48 hours from the time of pitching. The gravity of the wort will by this time, according to circumstances, have been reduced to from one-half to two-thirds of its original gravity. It is at this point that the separation of the yeast from the wort begins in the cleansing and skimming systems, and it is also the point at which the treatment of the beer on the different systems diverges.

Cleansing System.—The wort is pitched at 56° to 60° F., and when its gravity is reduced about one-half, and its temperature has risen to about 70°, which is generally reached in 36 to 40 hours after pitching, it is run into the cleansing casks, loose pieces, or Burton unions. The temperature is easily kept down

in the small casks to 70° in winter. Where the casks have no attemperators the beer is run down at a somewhat lower temperature in summer. The casks must be kept continually full by feeding or topping up by hand, as otherwise the yeast is not completely ejected, some of it, sinking to the bottom, and the beer is likely to acquire a yeasty taste. (See also above under "Loose Pieces" and "Burton Unions.")

Skimming System (according to Sykes).—In this system the fermentation is started in the same way as in the cleansing system, but when the skimming point is reached, the wort, instead of being run off into cleansing casks, is well roused. As soon as the head begins to assume a distinct yeasty character it is skimmed off once in every six hours, or even oftener, by hand or special apparatus, and the wort which passes off with the yeast should be freed from the latter and returned to the vat. When the temperature of the fermenting wort has risen to about 59° F., the attemperator is started slowly, and the flow of water through it is so regulated that the heat is allowed to rise half a degree every three hours. When the temperature has reached 65° to 66° F. the attemperator is put into more vigorous action in order to prevent any further rise of temperature. As soon as the process of fermentation begins to slacken, the temperature is lowered till it reaches 60° F. Skimming is kept up till the wort is judged to be able to throw up just one more head of sufficient thickness to protect it from atmospherical contamination.

The right point to stop skimming is found by pushing a small portion of yeast on one side and examining the surface of the beer thus exposed. When this appears black and clear, denoting that there is scarcely any more yeast in suspension, skimming is stopped, and the head which subsequently forms is allowed to remain undisturbed.

Dropping System (according to Thatcher, Brewing and Malting, Practically Considered, 1898).—This system is so thoroughly suited for producing modern light gravity pale ales that its adoption will ultimately become general among the brewers of the United Kingdom. The beers after being fermented in rounds or squares, as usual, until the skimming point is nearly reached and the correct temperature attained, are then dropped into suitable vessels, situated upon a lower floor. These dropping vessels are generally squares or rounds, rather shallow, preferably constructed of slate, or wood, copper lined, the shallowness inducing expulsion of yeast by surface attraction, consequently clearer beers are attainable. Attemperators are fixed in both top and bottom vessels. After dropping, the beers are treated as upon the ordinary skimming system, removal of yeast, attemperation, etc.

By dropping the beer, the yeast is thoroughly aerated and thus stimulated to vigorous reproduction. The dirty head, containing hop-resins, bacteria and other foreign matters, is left in the top vessel, consequently only a fresh and clean supply of yeast rises in the dropping vessel.

Following is a typical fermentation of an 18 pound (12½ Balling) beer:

		F.	Pounds.	
Wednesday,	7 p. m.,	59	18.0,	added 1½ pounds yeast per barrel.
Thursday,	7 a. m.,	59¾	17.3,	throwing off the blanket.
Thursday,	7 p. m.,	61	16.0,	rocky, alpine-looking head, dirt removed as it arose.
Friday,	7 a. m.,	64	14.0,	frothy head, attemperator on.
Friday,	7 p. m.,	69½	10.2,	run to dropping square.
Saturday,	7 a. m.,	70	7.5,	attemperated, skimming every three hours.
Saturday,	7 p. m.,	70½	5.0,	attemperator off, skimming every three hours.
Sunday,	7 a. m.,	69½	5.5,	last skim, afterward added priming solution.
Sunday,	7 p. m.,	67½	5.5,	settling, attemperating hard.
Monday,	7 a. m.,	62	5.5,	settling, attemperating hard.
Tuesday,	7 a. m.,	58½	5.5,	racked.

Yorkshire Stone Square System (according to Wright, A Handy Book for Brewers, 1897).—This system is not gaining in favor. The necessary number and costliness of the vessels are against it, also the difficulty of maintaining thorough cleanliness on account of the liability of the stone slabs to crack under the influence of boiling water.

The yeast is usually mixed with wort in the upper square (see above), and then allowed to run into the lower, which has been filled or nearly filled. Periodical rousing by means of a pump, the number of strokes given increasing with each repetition, is the cornerstone of this system. It begins between 20 and 30 hours after pitching, with the pump-rousing of the contents of the upper square, which has had some inches of wort left in it, now, however, allowed, by opening the valve, to flow into the lower square. Subsequent pumpings are from the lower square into the upper, whence the wort flows back into the lower again, through the open valve, these pumpings being continued at intervals, till the degree of attenuation is reached at which yeast begins to form. The yeast works out of the manhole into the upper square, and the beer or wort which separates

from it flows back into the lower square, through the valve. The latter is left open till the fermentation has nearly reached its term, when it is closed for good, any excessive formation of yeast being afterward skimmed from the manhole. Owing to the enormous degree of aeration and the mechanical rousing which the fermenting worts undergo, the range of temperature can be very much restricted. It rarely exceeds 6° F., compared with the normal 9°, 10° or even 12° of ordinary systems.

Cleansing in Pontos.—This system is dropping into disuse altogether.

RACKING.

After the yeast-making has ceased, the beer is allowed to rest for 24 to 48 hours, so as to deposit the bulk of the yeast held in suspension, and as soon as it has become sufficiently settled it is run off either into the store or the trade casks, care being taken to avoid any agitation which would cause excessive frothing and the rise of yeast in the tun.

All casks must be thoroughly steamed before filling. After racking, the packages are bunged and brought to the cellar, the bungs are again removed that any excess of yeast may work out, and the packages are filled with clean, bright beer. The stock beers usually receive a porous spile or bung to give necessary vent.

DRY HOPPING.

Ales usually, and black beers sometimes, receive an addition of hops in the storage or trade cask, the quantity varying from one-quarter pound for mild ales to one pound per barrel for pale, bitter and stock ales. The kind of hops used for this purpose are Bavarian, California, Mid-Kent and Sussex (Thatcher). The beer, through dry hopping, acquires greater stability and hop flavor, while the tannic acid of the hops promotes clarification. The hops are introduced into the empty cask by means of a wide funnel, through which hops are pushed with a short wooden rod, care being taken that the hops are simply loosened and not broken into fragments (Sykes). Hops contain diastase, which degrades certain types of malto-dextrins, so that they become fermentable.

SECONDARY FERMENTATION.

Stock beers undergo a secondary or slow fermentation in the storage or trade cask. If this fermentation is unusually lively, the beer is said to "fret" or "kick up." The secondary fermentation is carried out, not by the same yeast that fermented the sugar during the principal fermentation, but by other types, often wild yeast. The malto-dextrins of the beer supply the substance for this fermentation, being partly degraded by inversion enzymes contained in the yeasts and by the diastase introduced in dry hopping. Thus, beers that are dry-hopped ferment down lower in the cask than beers unhopped in cask, like most black beers. The fermentation of the sugars formed by the breaking down of the dextrins, keeps the beer charged with carbonic acid gas, and this condition is essential for checking the development of foreign ferments. Therefore, a sound secondary fermentation is of the greatest importance. Most English beers are sent out directly after racking, dry hopping and fining, and before secondary fermentation has set in, the demand for stock beers having diminished more and more in late years; or, the secondary fermentation is hastened by frequently rolling the casks for the purpose of keeping the yeast in suspension, and the beers are sent out after a storage of a few weeks.

Priming.—Often a solution of some kind of sugar is added to the beers, especially the black beers, in the cask, which process is called priming. The object is to impart sweetness or body, or to aid secondary fermentation and give "life" or what in England is termed "condition" or "briskness." In the former case glucose is added, while for briskness, priming with invert-sugar is recommended. The priming syrup prepared for this purpose should have the full strength permitted by the excise regulations, that is, a specific gravity of 1,150, or about 40 per cent Balling. Priming is also practiced where beers show abnormal turbidities, or cold water extract of malt may be prepared and added in cask to produce a more vigorous secondary fermentation.

Vatting.—In many breweries it is still customary to blend a young beer with an old one that shows acidity and proper flavor in a marked degree, in order to give the product the character of age. Especially is this done with stouts. The old beers are called vats, and as much as 25 per cent is blended at times with the young beer. "The first requisite," says Wright, "is that the vats should come into rapid blending condition, which implies a high degree of acidity, short of sourness, however, coupled with absolute brilliancy, results which are generally secured by fermenting beers of no remarkably high gravity at high temperatures, and supplementing this with rousing and aeration. If the ordinary English system be followed, vatting is perhaps the only way of getting that amalgamation of flavors which characterizes a perfect stout. Accordingly a blend of a vatted stout, having a gravity of 30 pounds (20 per cent Balling) or higher—the higher the better—with a sweet running porter of say 18 to 19 pounds gravity (12 to 13 per cent Balling) will certainly give far better results than a single stout brewed at 24 to 25 pounds gravity (16 to 17 per cent Balling), and sent out unblended."

Worting.—Stout and porter for immediate draught often, besides being blended with vatted stout, receive an addition of unfermented wort varying from half a gallon to a gallon and a half per barrel (Southby, Practical Brewing). Those stouts which are intended for bottling and export must not be worted.

Finings are added either before the beer is sent out, or by the customer in his cellar. About one pound of good isinglass is made up to about 10 gallons, according to processes familiar to the American brewer, the cold method of preparation being employed, and tartaric acid and sulphurous acid are usually used in cutting. About one to two pints is added to a cask (1½ U. S. barrel).

Beer Storage (according to Southby).—Beer may be stored either in the casks in which it is to be sent out, or in vats of larger or smaller size. In former days, vatting was almost universal, but since the great success of the Burton ale breweries, vatting has gone more and more out of vogue, and is now almost confined to the storage of the stronger class of black beers and some special varieties of strong ale. For stout, the vatting system seems alone capable of inducing those peculiar changes and the development of those ethers and flavors so much valued in the finest productions of the London and Dublin porter brewers.

When storing ale in casks, it is necessary to provide against the excessive development of carbonic acid. This is usually effected by the use of the porous spile.

These spiles are made from the wood of the American black oak, which is full of tubular cells running in the direction of the grain. They are made about an inch long and turned slightly conical. They are not pointed, but both ends are flat and cut across the grain, thus allowing an egress for the carbonic acid as it is generated. As, however, they flatten the beer to some extent, they should be replaced by tight spiles a short time previous to the beer being sent out for consumption. When beer has been long stored, the tubes of the porous spiles become clogged with yeasty and extractive matters, so that after a certain time they cease to allow any gas to escape. Therefore, fresh porous spiles should replace the old ineffective ones where beers are stored for a very long time.

By storing beer in good cellars, in which a uniform temperature of about 54° F. is maintained, almost all risk of the beer becoming acid is avoided, provided it is well brewed and from good materials. There are, however, some inconveniences in this method of storage, for, if the cellars are very cool the beers stored in them are apt, when removed into a warmer atmosphere, to kick up, owing to their not having previously gone through that slow fermentation in cask which is sure to take place sooner or later in all stock beers. On the other hand, if the cellars are maintained at a somewhat higher temperature, the beers are apt to chill and become cloudy when removed in cold weather.

The fact is, that by coddling beers, while you certainly preserve them from disease, you are sure, at the same time, to render them tender and susceptible to every change of temperature. Burton beers, in former days, were exposed by day to the heat of the sun, and by night to the frost, and, by this treatment, they became so hardy that they retained their condition and brilliancy under the most adverse influences. In Burton the usual practice is (Southby, 1889) to stack up the casks in open yards, covering them up by means of hurdles wattled with straw. As the warm weather comes on, further protection becomes necessary, and the casks are either placed in the now vacant malt house, or the straw is frequently wetted during the day by sprinkling it with water.

Ales of sufficient strength, or pale ales in which a large proportion of hop has been used, can be stored in this rough manner with safety, but a great risk is run with the lighter class of ales unless they are stored in cool cellars.

BOTTLE BEERS.

According to Wright, ale for bottling should be allowed to go through all its cask changes, spontaneous brilliancy (un-

aided by finings) at the end of them being the simplest criterion of ripeness for bottling.

The temperature of the bottling cellar should not exceed 55° F. (10° R.), and may well be lower, and a fair amount of ventilation, if it can be managed, with a uniform temperature is desirable. When bottled, however, a higher temperature is required to insure proper condition, say from 58° to 60° F. (11½° to 12½° R.); but note that too speedy maturity is not to be wished for, pointing, as it does, to faulty brewing or incomplete secondary fermentation.

Messrs. Bass & Co. used to issue the following instructions to their agents:

"The proper season for bottling pale ale commences in November and ends in June.

"Pale ale should not be bottled during the summer months, nor after hot weather has set in, even though the temperature should afterward become cool.

"The ale should be placed bung upward in a cool, ventilated store, about 50° to 55° F. temperature.

"If the ale should get into a brisk state of fermentation, a porous cane or porous oak spile should be inserted in the bung until the excessive fermentation has subsided, when a tight, close peg should be substituted.

"Ale should never be allowed to become flat.

"It should be bright and sparkling when bottled, but not fermenting. The bottles to be corked directly they are filled.

"In bottling, a tap with a tube reaching toward the bottom of the bottles should be used.

"When corked, the bottles to be piled standing upright and not lying on their sides.

"When the ale becomes ripe, a sediment will be deposited in the bottles. In uncorking be careful not to disturb it, but empty the contents of the bottle into a jug, keeping back the sediment."

A simple test for bottling fitness is to fill a clean bottle with the beer and keep it at a temperature of about 90° F. (26° R.) (see "Microscopical Laboratory") for about four days. If no deposit shows within this time, good results may be expected.

TURBIDITIES AND OTHER DISEASES.

Beer Turbidities.—These are brought about by much the same causes as those affecting lager beers under certain circumstances. Their treatment is much more difficult since the beers are stored mainly in casks, and filtration cannot be resorted to. Recourse is, instead, had to the addition of finings. Beer turbidities may be caused by:

Weak Yeast.—If the yeast in the storage cask is the progeny of a weak yeast, it is apt to be light, settles slowly and rises upon the slightest provocation. Greatest attention must be given to the stock yeast to keep it in a condition of strength and purity. Yeasts from medium gravity worts give the best results, as those from very high gravities are apt to be overfed and sluggish, while low gravity worts may not satisfy the yeasts in point of nutrition. The precautions to be used in selection, general treatment, strengthening and purifying of the yeasts are much the same as for bottom-fermentation yeasts.

Wild Yeast.—The types of yeast causing cloudy frets are *Sacch. pastorianus III* and *Sacch. ellipsoideus,* both of which, according to Matthews and Lott, may cause a distinctly unpleasant smell and flavor or stench, but beers which have gone through such frets may, if otherwise sound, become quite palatable.

Another wild yeast type found to cause beer turbidity is *Sacch. exiguus,* a light, elongated yeast. In this case the turbidity, according to Matthews and Lott, is prolonged and accompanied by marked flatness, which is probably not unconnected with its inability to ferment maltose.

Bacteria Turbidities.—The bacteria most frequently met with in beers, and those which cause undue turbidities besides souring and, in some cases, stench and ropiness, are sarcina, lactic forms, *saccharobacillus pastorianus* (these three produce souring). Butyric forms may produce a disgusting smell, and are sometimes found in returned ales. (Matthews and Lott. The Microscope in the Brewery and Laboratory, 1899). *Mycoderma aceti* or *bacterium aceti,* often found in returned ales, causes marked acidity even when ales are only moderately infected.

Ropiness.—This is a condition of the beer of being highly viscous so that it flows like thick oil or even hangs in strings when poured. It seems to be due to organisms, but the question is still in doubt. Slack malt, light hopping and imperfect cleansing seem to favor viscous fermentation. Van Laer succeeded in causing ropiness in sugar solution by infection with two kinds of bacillus, which he calls *bacillus viscosus I* and *bacillus viscosus II,* and it is known that an organism called *Leuconostoc mesenteroides* has the power of converting large quantities of the juice of the sugar beet into a viscous, syrupy mass. *Pediococcus viscosus* has been found to cause ropiness in German Weissbeer.

Albuminoid and so-called hop-resin turbidities seem as yet to be little understood in England. As to albuminoids, it would seem that this form of turbidity admits of a ready explanation, as the high initial mashing temperatures employed in England favor the formation of proteids of a kind that do not readily precipitate (see "Peptase and Albumen") and make their appearance when the beer is cooled to lower temperatures. (See also "Principles of Brewing.") In America much attention is given to avoiding this form of turbidity, since the lager beers are stored and consumed at much lower temperatures than ales or stouts, and relatively small quantities of albuminoids, or proteids, as we call this objectionable class of albuminoids, make their presence known, on account of their almost absolute insolubility at temperatures near freezing point.

Starchy Turbidity: (See "American Lager Beers.")

Beer Sickness Due to Dry Hopping.—Sometimes fermentation is too quickly accelerated in the cask by the addition of hops and a permanent "fret" ensues, while at the same time an unpleasant flavor becomes noticeable. This may be caused by organisms introduced with the hops.

Yeast Bite is a condition of the beer of having a bitter clinging disagreeable taste. This is attributed by English authorities to a number of causes, such as too high temperatures at the end of primary fermentation, insufficient aeration, or the presence of foreign organisms, such as Sacch. pastorianus I.

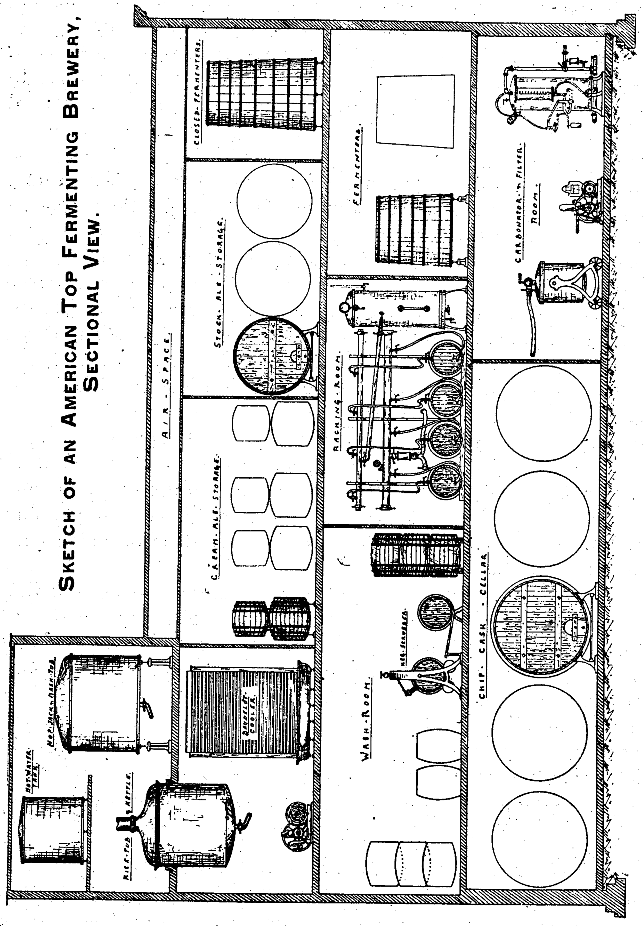
Bisulphite Smell or Stench is attributed to the reducing action of bacteria or even yeast on the sulphurous acid it contains, in which case sulphuretted hydrogen is formed.

TOP-FERMENTATION BEERS IN THE UNITED STATES.

AMERICAN ALES, PORTERS AND STOUTS.

In the United States a somewhat different system of brewing has developed in the production of top-fermentation beers, from those employed in England. While the American stock beers are patterned after the English stock ales and stout, *cream, lively,* or *present use ale* takes the place of the English mild ales, and more recently the American ale brewers are equipping their plants

Sketch of an American Top Fermenting Brewery, Sectional View.



(The publishers are indebted for this sketch to Mr. C. Haefner. It will be seen that proportions have been ignored for reasons of space, since if the smaller vessels and implements had been drawn to the same scale as the big ones, they would appear too minute. The arrangement is the principal thing intended to be shown.)

with refrigerating machines to brew a beer—*brilliant or sparkling ale*—that combines the properties of lager beer and ale, i. e., a sparkling, brilliant beer with an ale taste and aroma. Since these ales have been put on the market, top-fermented beers have gained some of the ground which they had lost in competition with lager beers.

In the main, the equipment of a modern American ale and porter brewery does not differ essentially from that of a lager beer brewery. The chip-cask cellar of the lager beer brewery, however, can be dispensed with, a carbonating room taking its place, while the stock cellar is retained, since some of the ales are stored.

CREAM OR PRESENT USE ALE.

Material.—Seventy per cent of malt, 30 per cent of unmalted cereals; or 75 per cent of malt, and 25 per cent of sugar added in the kettle.

Mashing Method.—Initial temperature 122° F., hold 30 minutes, run in corn mash, hold at 154° F. for 30 minutes, run up to 162° F., mash until conversion is complete, rest one hour, tap, boil like lager beer, adding from one to one and one-half pounds of hops per barrel. Add sugar (if used) 30 minutes before running out. Balling of wort, 14 per cent. Cool, give from one-half to one pound of yeast per barrel. Use skimming system. After yeast-making is over, let settle for two days, fill into trade barrels, and add 10 per cent Kräusen taken 36 hours after pitching.

For treatment of grits, flakes, etc., see "Mashing Operations" for Lager Beer.

BRILLIANT ALE.

Brew like present use ale. Balling of wort from 13 to 15 per cent, hops one and one-half pounds per barrel.

Fermentation.—Skimming system. (See "Stock Ale" and "Brewing in England.") After yeast-making is over let settle for two days, bring into storage tanks at temperature of cellar (44° F.). Add finings, pump over in 5 to 6 days, fine again, cool to 36° F., carbonate, filter and rack, or run from storage tanks to chip-cask when there is no carbonator, fine with isinglass and treat generally like lager beer. Temperature of chip cellar about 39° F.

Kräusening with lager beer Kräusen cannot be recommended, as the character of the product then approaches too much that of lager.

STOCK ALE.

Material.—Pale malt alone, or with 25 per cent of sugar.

Mashing Method.—Initial temperature of mash from 149° to 151° F., run hot water through underlet or pfaff to raise the temperature to 154° F., mash until inversion is complete, rest for one hour, use from two to three pounds of hops per barrel, adding one-third after all the spargings are in and wort boils, one-third after boiling one hour; boil one hour longer, and add the last one-third about ten minutes before running out. Balling 16 to 18 per cent. If sugar is used, add 25 per cent 30 minutes before running out.

Sparging water should have following temperatures: First, 176° F.; second, 170° F.; third, 165° F.; fourth, 165° F. (See also "Brewing in England.")

Fermentation.—Cool the wort to 59° F., add one and one-half pounds of yeast per barrel, let temperature rise to 70° F., after 36 hours rouse for 30 minutes, and run the ale into skimmers, i. e., vats in which the yeast is skimmed off. After yeast-making is over let settle for two days, run into trade barrels, add one-quarter pound of a good quality of dry hops per barrel, and prime with one pint of a 30 per cent solution of cane-sugar per barrel. Store from three to four months. (See also "Brewing in England.")

STOUT AND PORTER.

The principal requirements, as compared with ale, are greater palate-fulness, pronounced malt flavor and darker color. It is best to use mixed malts, i. e., a mixture of high and low kiln-dried malts. If this cannot be had, caramel malt, "black" malt, and sugar coloring to the required amount should be added.

The mashing method and general treatment of porter and stout are the same as for stock ale.

Hops.—Porter, one and one-quarter pounds per barrel; stout, two and one-half pounds per barrel. Added in the same manner as to stock ale. Sugar (if used) to the amount of 25 per cent, added in the kettle 30 minutes before running out. Porter, 13 per cent Balling strong; stout, from 16 to 18 per cent Balling.

Fermentation like stock ale. No dry hopping. Store three to four months.

BOTTLED GOODS.

Stock beer for bottling (ale or stout) should go through ordinary cask-fermentation (secondary fermentation) and after about three to six months it should be filled in bottles, while moderately lively, at from 65° to 70° F., when it will raise sufficient gas to become brisk again and have a pungent flavor. Beer bottled previous to secondary fermentation becomes too wild in the bottles. The bottle stock beers are not pasteurized. (See also "Brewing in England.")

AMERICAN WEISSBEER.

The process of manufacture of this beer may be copied from the German methods. However, the material employed and method of mashing is usually quite different. Wheat malt is sometimes, but not generally, used. Instead, grits are employed to the amount of about 30 per cent, together with pale malt. The grits are treated as usual, the mash is started at about 40° R. (122° F.), and temperature raised by addition of grits mash and water to about 58° R. (162° F.). The wort is boiled for a short period (about 30 minutes) with hops from one-half to three-quarters pound per barrel.

Strength of wort about 10 to 12 per cent Balling.

For treatment of beer during fermentation, see "Berliner Weiss Beer." Ale yeast should not be employed as is often the case, but yeast from a Weiss beer yeast should be obtained in case of need. In America the fermentation is generally conducted in vats instead of casks, in which case the yeast is skimmed off.

After fermentation the beer is kräusened and filled in bottles.

Undoubtedly the American article could be much improved by employing the materials, as well as the mashing method in vogue in German Weiss beer breweries, especially the material, as grits will under no circumstances yield those albuminoids that give Weiss beer its character, as wheat malt does. Certainly there seems no reason why American Weiss beer brewers should not be able to procure a good wheat malt.

Weiss beer in America is sometimes stored, bunged, and fined like lager beer, but a brilliant Weiss beer does not seem to catch the fancy of the consumers, who are accustomed to the cloudy, lively article of Berlin fame.

For details of Weiss beer production in Germany see next page.

KENTUCKY COMMON BEER.

Like California steam beer, Kentucky common beer is mainly consumed by the laboring classes, and is chiefly brewed in Louisville, Ky. It is marketed while still in an early stage of fermentation.

Materials employed are: Barley malt and about 25 to 30 per cent of corn, with some sugar color, caramel or roasted malt to give a dark color.

Balling of wort about 10 to 11 per cent.

Mashing temperatures vary greatly, both low and high initial temperatures being taken. In the latter case the corn mash is cooled with water before running into the mash-tun.

Boiling.—The wort is boiled with about one-half pound of hops per barrel, and cooled to 60° F. (12° to 13° R.).

Fermentation.—The wort is pitched with one-third of a pound of top-fermentation yeast per barrel, allowed to come full in Kräusen, and then transferred from the fermenter directly into the trade packages, which are placed on troughs, into which the yeast is allowed to work out. The barrels are kept full continually by topping up every few hours. After 48 hours in the barrels the fermentation is over and the barrels are bunged; when very much gas is required they may be closed in 24 hours.

The beers are not as a rule Kräusened, nor fined, and consequently have a "muddy" appearance, but a moderately clear article can be obtained if the saloonkeeper lays in a supply so that it can settle a few days before tapping.

TOP-FERMENTATION GERMAN BEERS.

BERLINER WEISSBEER.

Of the many varieties of top-fermentation German beers, it is only *Weiss beer* that has been able to compete with the lager beers, while the others, being gradually displaced, are but little known, or enjoy only a local reputation.

Although the methods for the production of Weiss beer vary considerably in different parts of Germany, it may be of interest to consider only the Berliner Weiss beer, as that is the kind which seems to have outstripped its rivals in Germany in point of quantity consumed, as well as in the United States, where it is considered the one type worthy of imitation.

Berliner Weiss beer should have a very pale color; be moderately clear, distinctly tart, rich in carbonic acid, so that it foams strongly when poured, and should hold the foam moderately well.

There are quite a number of variations of methods employed in the production of this beer, even in Berlin, but we will content ourselves with giving only one in detail.

The Materials employed are wheat malt and barley malt, hops and water. Three parts of wheat malt to one of barley malt was formerly considered to be the proper proportion, but since a greater degree of transparency is required of the product, the inclination is of late to take less wheat malt. The original Balling of wort is about 10 to 12 per cent, amount of hops about three-quarters of a pound per 100 pounds of malt, or about one-quarter of a pound per American barrel.

The water employed should contain some salt and gypsum. If it does not, it may be prepared by adding about five pounds of table salt per 100 barrels, and as much gypsum.

Mashing Operations.—Three parts of wheat malt previously dampened, so as not to be crushed too finely, and one part of barley malt are run through the fore, or outside, masher, together with cold water, and the temperature raised by running in hot water from the mash pan to the very thick mash until 38° R. (118° F.) is reached. Part of the hot water (about one-third) is left in the pan, to which about three-fourths pounds of hops is added per 100 pounds of malt, and boiled from 20 to 30 minutes. Then, a "lauter-mash" is drawn, run into the pan, and boiled together with the hop decoction for a few minutes and returned until the temperature of the mash reaches 48° R. (140° F.). The first thick mash is then drawn, boiled five minutes and returned, bringing the temperature of the mash up to 55° R. (154° F.). A second thick mash brings the temperature up to 60° R. (157° F.).

The mash now rests about 40 minutes, when the wort is tapped and immediately run over the surface cooler and through pipe cooler, into the fermenter, where yeast is added.

It is noteworthy that the Weiss beer wort is not boiled, and consequently the genuine Berliner Weiss beer is not so clear, owing to the large amounts of proteids it contains, in comparison to those beers for which the wort is boiled, as is the case with Rostock, Hanover, Thuringian and Saxon Weiss beer.

Fermenting Operations.—The pitching temperature is about 12° R. (59° F.) in summer and 14° R. (64° F.) in winter. The yeast may be added to a small quantity of the first wort, say ten pounds per barrel, and when in Kräusen, mixed with the wort in the starting tub (Ansetzbottich), letting the remainder of the wort run in as it comes from the cooler, rousing from time to time as long as it runs. The amount of yeast may be from one-half to three-quarters of a pound per barrel. The temperature during fermentation should not rise above 18° R. (85° F.), and should preferably be kept down to 16° R. (68° F.).

Some time after pitching a white foam becomes noticeable, and the beer is then transferred to the fermenting casks or barrels, holding usually about 30 to 90 gallons, where the foam, and subsequently the yeast, is allowed to work out of the bunghole into a trough, or a yeast vat, that is placed between two casks, laid so that their bungholes incline toward each other over the yeast vat. Soon a white foam is ejected out of the bunghole, which is collected in the yeast vat, and the beer collected from this collapsing foam (Abseihbier) is subsequently used for "topping up."

About 24 hours after pitching, yeast makes its appearance, the foam becoming more sticky, yellow, and larger bubbled. The yeast-making continues for about 24 to 30 hours, and during this time the foam is gathered in clean yeast vats, and the casks must be continuously kept full by topping up, as otherwise the yeast would not work out properly, would partly sink in the beer and impart to it a yeasty taste.

The fermented beer, with 3 to 5 per cent Balling, is drawn into separate casks, where it receives an addition of Kräusen, either at once or as soon as the beer is wanted. The amount of Kräusen depends upon the presumable length of time that the beer is to keep before consumption.

The beer, after Kräusening, is at once filled into bottles or jugs, where it is kept for about 8 to 14 days before it is ripe. Such beer receives about 25 per cent of Kräusen. If it is intended to keep longer it receives less Kräusen, as is the case for the export article, which is expected to keep four or six weeks in the bottle in a cool place.

The beer forms a heavy yeast sediment in the bottle, for which reason it must be carefully poured, after opening the bottle with caution to avoid agitation.

BROYHAN.

This is a Weiss beer, first brewed in Hanover as far back as the beginning of the sixteenth century. The genuine article has the appearance and bouquet of young wine, and a sweetish, tart taste. It is produced from barley malt and hops, without wheat malt, and is but slightly fermented. Single Broyhan is brewed with about 8 per cent Balling, double Broyhan, about 12 to 13 per cent Balling. The beers contain a low percentage of alcohol.

Beers similar to Broyhan are *Kotbusser Beer* and *Goslarer Gose.*

GRAETZER BEER.

This is a peculiar German local beer, produced from about two-thirds of smoked wheat malt, and one-third of barley malt. The wheat is steeped for 30 to 40 hours, germination is allowed to proceed at rather high temperatures so that the rootlets mat densely. Oakwood is used for fuel in drying the malt, the smoke passing through the malt, giving it a peculiar odor. The final kiln temperature is 40° to 45° R. (122° to 133° F.).

The wort is made on the infusion plan; initial temperature 20° R. (77° F.), end temperature 58° to 60° R. (163° to 167° F.), produced with hot water in about an hour. The wort is boiled as usual, one and one-quarter pounds of hops being added. Gravity of wort 7½ to 8½ per cent Balling. Hops are strewn over the grains before sparging.

Fermentation is carried out as for Weiss beer, after which it is put into packages of one to two barrels, which are bunged and left to stand for two to three weeks. Then the beer is bottled and stored at a temperature of about 8° R. for about two to three months.

The color of the beer is like that of Pilsener, and the taste is said to be deliciously tart and wine-like.

SPONTANEOUS FERMENTATION BEERS.

BELGIAN BEERS.

The first beer fermentations known were, of course, incited by yeasts finding their way accidently into the wort, and many local beers in different countries are still produced on this plan. But nowhere have such beers so extensive a market as in Belgium, where lager beer breweries are very few and where the top-fermentation beers divide honors with the spontaneous fermentation types, of which there are three: *Mars, Faro* and *Lambic.*

Mars is a beer of little gravity, Lambic is of high gravity, Faro of medium gravity.

Materials: These beers are made with 40 to 50 per cent of raw wheat, mixed with barley malt.

Mashing Methods.—The mixture is put into the mash-tun, water is run in, giving an initial temperature of about 40° R. (122° F.). Part of the mash then goes into the mash pan where it is saccharified at about 54° R. (154° F.), then boiled and returned to the main mash, raising the temperature to about 52° R. (149° F.). Another thick mash is taken, raising the temperature after its return to 56° R. (158° F.), and a third thick mash brings it to 60° R. (167° F.). This wort is very dextrinous.

Fermentation.—When it has cooled to about 8° to 10° R. (50° to 54° F.) it is run at once into casks, receiving no yeast whatsoever. There it ferments by means of wild yeasts. The casks are stacked one over the other and communication with air is allowed through a very small hole. Fermentation becomes noticeable two or three days, sometimes a week, after the wort has been introduced into the cask, depending mainly upon the temperature of the cellar. A black, thick liquid oozing out through the hole indicates the progress of fermentation. After about two weeks of fermentation this hole becomes closed, owing to the thick liquid drying and becoming solid. The beer is then left in storage for a long time, extending up to two, three or even five years.

It is brewed only in the winter from October to April. Every year, when summer comes, this beer begins to work again. After two years it remains still. The brewer samples the casks, and if the beer is very bright, the taste clean and to the customer's requirement, it is taken out and run into the shipping casks.

The beer so obtained is very acid, containing great quantities of lactic acid. The very acid Lambic is bottled and keeps very long. It is called *gueuse lambic*. These beers are often seasoned with sugar. Then they constitute a drink that is both sour and sweet

COMPOSITION OF VARIOUS BEERS.

AMERICAN LAGER BEERS.	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By	Obtained In
Average of 14 samples........	1873	5.1	13.85	.....	3.83	6.19	0.69	1.63	0.189	0.30	0.116	Doremus,	New York.
Average of 170 samples........	1885	4.00	13.30	90.45	3.75	5.80	.....	...	.....	0.26	0.096	F. E. Engelhardt,	New York.
Av. of 222 samples of lager beers from all parts of U. S.	1873/87	4.1	13.49	90.36	3.85	5.79	0.62	1.53	0.124	0.26	0.095	Doremus, Engelhardt Crampton, Lattimore	New York. Different States.
Average of 15 samples........	1887	4.53	13.73	.....	3.77	6.46	0.51	2.00	0.16	0.194	0.072	Wahl and Henius.	Different States.
Average of 88 samples	1889	4.85	13.30	.....	3.64	6.21	0.50	1.99	0.11	0.20	.....	"	Different States.
Average of 210 samples.......	1890	3.93	13.45	.....	4.01	5.70	0.56	1.20	0.10	0.18	.....	"	
Average of 176 samples. ...	1893	3.66	12.53	.....	3.61	5.50	0.390	1.62	...	.....	.....	"	
Beers from 10 different cities. A.	1895	3.30	12.35	.....	3.72	4.91	0.41	1.29	0.09	.....	0.066	"	
B..	1895	4.64	13.04	.....	3.45	6.15	0.39	1.62	0.120	.....	0.058	"	
C.	1895	4.09	14.23	.....	4.16	5.92	0.44	1.83	0.103	.....	0.060	"	
D..	1895	2.88	13.62	.....	4.41	4.80	0.45	1,39	0.102	.....	0.069	"	
E..	1895	3.82	12.46	.....	3.53	5.46	0.37	1.45	0 135	.....	0.075	"	
F.	1895	2.91	12.18	.....	3.81	4.56	0.33	1.50	0.069	.....	0.053	"	
G.	1895	4.00	11.93	.....	3.26	5.41	0.48	1.97	0.085	.....	0.068	"	
H.	1895	4.97	14.57	.....	3.82	6.73	0.46	3.36	0.126	.....	0.075	"	
I..	1895	3.12	13.45	.....	4.25	4.95	0.33	1.50	0.073	.....	0.060	"	
J..	1895	3.37	13.10	.....	4.00	5.10	0.35	1.25	0.054	.....	0.060	"	
Average of 247 samples.......	1896	3.60	12.93	.....	3.82	5.29	0.46	1.62	0.101	.....	0.068	"	Different States.
Canadian lager...............	1900	3.15	12.1	.....	3.77	4.88	0.61	1.13	0.072	.....	0.063	"	
Mexican lager................	1900	3.37	12.51	.....	3.77	4.97	.....	1.61	....	.....	.....	"	
Mexican lager	...	.....	13.27	.....	4.01	5.25	0.5	1.114	0.124	0.203	0.089	A. Long.	
Am. tonics, Av. of 10 samples.	1896	6.81	18.61	.....	4.88	8.85	0.67	3.88	0.141	.....	.....	Wahl and Henius,	
Some typical American tonics. A..	1895	7.82	17.27	.....	3.88	9.51	0.63	3.87	0 208	.....	0.105	"	
B,	1896	13.74	18.74	.....	2.06	14.62	0.85	9.84	0.113	.....	0.140	"	
C,.	1896	7.41	20.78	.....	5.50	9.78	0.64	4.94	0.180	.....	0.107	"	
D..	1896	5.23	17.01	.....	4.87	7.27	0.51	2 60	0.090	.....	0.085	"	
E..	1896	5.47	16.86	.....	4.69	7.48	0.88	2.87	0.212	.....	0.129	"	
F..	1896	7.58	17.46	.....	4.06	9.54	0.77	0.96	0.288	.....	0.155	"	
G..	1896	8.20	21.70	.....	5.69	10.72	1.26	3.58	0.216	.....	0.144	"	
Some typical Am. temperance beers. A..	....	2.15	6.66	.....	1.88	3.05	0.18	0.85	0.063	. .	0.03	"	
B..	....	5.50	8.31	.....	1.22	6.07	0.09	2.55	0.036	.....	0.02	"	
C..	....	3.27	6 66	.....	1.44	3.90	0.19	2.55	0.025	.....	0.025	"	
D..	....	1.95	6.55	.....	1.94	2.80	.....	.....	.	.....	....	"	

COMPOSITION OF VARIOUS BEERS—(Continued).

ALES, PORTERS, STOUTS AND AMERICAN WEISSBEERS.	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract	Albuminoids	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.	Obtained In.
Ales.													
Bass & Co.'s Pale Ale	1896	1.8	14.96	....	5.58	4.32	....	0.76	0.234	....	.....	Doemens.	Munich.
Bass & Co.'s Strong Ale	1896	8.8	24.2	.....	6.85	11.8		3.81	0.288	....	.....	Doemens.	Munich.
Bass & Co's Pale Ale	1888	2.75	17	88.57	6.06	5.35	....	1.51	0.189	....	.....	C. Gottfried and C. Rach.	Munich.
Bass & Co.'s Pale Ale	1887	2.4	15.74	89.42	5.66	4.42	0.50	0.49	0.117	0.31	0.056	C. A. Crampton.	Wash., U. S. A.
Bass & Co.'s bottled Dog's Head	1901	0.87	16.08	89.85	6.45	3.70	0.58	0.67	0.171	....	0.0585		
Bass & Co.'s bottled White Label	1901	1.92	15.65	89.68	5.80	4.52	0.55	0.61	0.171	....	0.054		
Bass & Co.'s draught Pale Ale	1901	3.45	15.70	89.06	5.18	5.76	0.58	1.68	0.144	....	0.06		
Allsopp-Burton light dinner Ale	1896	2.0	13.35	.....	4.65	4.05	....	0.70	0.198	....	.....	Doemens.	Munich.
Allsopp-Burton Ale	1879	3.60	16.97	89.33	6.30	4.37	0.45	....	0.235	....	0.026	Lawrence and Reilly.	
Allsopp's India Pale Ale, Red Hand	1901	2.23	15.14	....	5.44	4.70	0.44	0.66	0.144	....	.045	Wahl and Henius.	Chicago.
McEwen's Sparkling Ale	1901	3.35	21.62	85.55	7.80	6.65	0.85	2.67	0.378	....	0.0765	Wahl and Henius.	Chicago.
Wm Younger & Co.'s Sparkling Ale, Monk Brand	1901	1.87	18.03	....	6.84	4.90	0.64	0.80	0.153	....	0.067	Wahl and Henius.	Chicago.
Olde English Ale, Dog's Head bottling	1901	3.92	21.39	....	8.75	7.59	0.91	1.60	0.162	....	0.0855	Wahl and Henius.	Chicago.
Somerset, draught ale, 3 years old	1882	2.15	22.63	85.71	8.57	5.49	0.71	1.36	0.63	....	......	Ch. Graham.	
Worthington Burton Ale, 18 months old	1890	7.50	24.2	..	7.85	....	....	....	0.3695	as		Brown and Morris.	
Worthington Burton, bottled, 90 years old	1890	7.50	25 8	....	8.70	....	....	....	0.6095	acetic acid		Brown and Morris.	
Hannover Pale Ale Union Br.	1884	2.50	15.46	....	4 51	6.44	0.78	....	0.138	0.24	0.095	J. Skalweit.	
Christiania Pale Ale Ringes & Co.	1884	5.7	14.45	88.19	4.00	6.45		....	0.13	....	.....	Zetterlund.	
American Ale	1887	4.50	16.52	88.73	5.25	6.02	0.57	1.47	0.094	0.33	0.057	C. A. Crampton.	Wash., U. S. A.
American Ale	1887	3.15	19 39	87.09	6.92	5.55	0.73	0.93	0.382	0.47	0.077	C. A. Crampton.	Wash., U. S. A.
American Stock Ales, average of 9 samples	1896	3.21	16.73	....	5.55	5.64	0.46	1.81	0.256	....	0.061	Wahl and Henius.	Chicago.
American Cream Ale	1901	2.25	13.60	....	4.75	4.45	0.37	1.06	0.144	....	0.04	Wahl and Henius.	Chicago.
American Sparkling Ale	1899	3.98	13.98	....	4.08	5.82	0.40	1.52	0.135		0.06	Wahl and Henius.	Chicago.

COMPOSITION OF VARIOUS BEERS—(Continued).

ALES, PORTERS, STOUTS AND AMERICAN WEISSBEERS. (Continued.)	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.	Obtained In
Ales—Continued.													
American Sparkling Ale	1901	2.15	13.80	.....	4.90	4.40	0 38	0.91	0.135	....	0.04	Wahl and Henius.	Chicago.
American Pale Ale	1900	3.56	13.05	.....	4.01	5.35	0 37	1.34	......	....	.....	Wahl and Henius.	Chicago.
Canadian Stock Ale	1900	3.20	14.45	.....	4.75	5.30	0.51	1.36	......	....	.....	Wahl and Henius.	Chicago.
Stouts.													
Guinness' Extra Bottled Foreign Stout, white label	1901	3.40	18.22	87.56	6.29	6.15	0.75	0.97	0.243	....	0.108	Wahl and Henius.	Chicago.
Guinness' Extra Stout	1896	4.50	17.6	.....	5.64	7.02	....	1.03	......	....	.....	Doemens.	Munich.
Allsopp Luncheon Stout	1896	2.97	15.58	.....	5.35	5.37	....	1.53	......	....	.....	Doemens.	Munich.
Victoria Stout	1888	2.35	15.62	89.68	5.36	4.90	....	1.30	0.0556	....	.....	Doemens.	Munich.
Dublin Single Stout	1879	6.1	15.18	89.74	4.92	5.34	0.43	...	0.222	acetic	0.115	C. Gottfried and C. Rach.	Munich.
Dublin Double Stout	1879	2.9	20.63	86.60	7.23	6.17	0.78		0.364	acid	0.173	Lawrence and Reilly	
Double Brown Stout, (Barklay, Perkins & Co.)	1884	4.0	18.78	87.28	6.00	6.78	....	....	0.46	0.39	....	V. Fodor.	Budapest.
Dublin Stout	1882	7.2	23.08	83.66	6.78	9.52	0.43	5.35	0.252	....	.....	Ch. Graham.	
English Stout	1887	3.7	18.16	87.57	6.13	5.90	0.76	0.57	0.151	0.37	0.049	C A Crampton.	Wash., U.S A.
American Brown Stout	1900	5.45	18.15	.....	5.37	7.83	0.56	2.06	......	....	.....	Wahl & Henius.	Chicago,
Porters.													
American Porter	1887	6.7	17.97	86.32	4.89	8.19	0.76	2.67	0.166	0.41	0.100	C. A. Crampton.	Wash., U.S.A.
American Porter	1899	2.95	13.25	.....	4.19	4.87	0.40	1.49	0.135	....	0.061	Wahl and Henius.	Chicago.
Canadian Porter	1900	4.00	14.30	....	4.37	5.91	0.53	1.31	0.162	....	.....	Wahl and Henius.	Chicago.
American Weissbeers.													
American Weissbeer	1900	2.52	9.29	.....	2.85	3.82	0.57	1.00	......	....	.....	Wahl and Henius	Chicago.
Weissbeer	1901	2.24	9.28	93.45	2.97	3.58	0.42	0.91	0.342	....	0.036	Wahl and Henius.	Chicago.

COMPOSITION OF VARIOUS BEERS—(Continued).

GERMAN, AUSTRIAN AND BOHEMIAN DOMESTIC BEERS.	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.
SCHENK OR WINTER BEERS.												
Pilsener, Bürgerl. Brauhaus	1886	3.55	11.20	91.79	2.98	5.23	....	....	.....	0.196	.....	Fr. Kundrat.
Simmeringer	18$\frac{81}{85}$	3.75	10.00	92.65	2.66	4.69	0.24	....	.....	0.15	0.051	L. Rosler.
Kleinschwechater	18$\frac{81}{85}$	3.00	10.13	92.81	2.94	4.25	0.26	....	.....	0.14	.. ..	L. Rosler.
Nussdorfer	1876	3.75	10.78	92.15	2.93	4.92	0.30	....	0.09	0.16	.....	Fr. Schwackhoefer.
Erlanger	18$\frac{74}{75}$	....	12.82	90.89	3.71	5.40	....	....	.....	0.23	.....	A. Hilger.
Muenchener	1866	4.25	11.92	.....	3.00	5.92	....	....	.....	0.25	.....	C. Lermer.
LAGER OR SUMMER BEERS.												
Bürgerl. Brauhaus Pilsen	1887	3.55	11.72	.....	3.32	5.08	....	....	0.12	0.18	.....	E. Geissler.
Actien—Brauhaus Pilsen	..	2.75	11.72	.	3.51	4.70	....	....	0.12	0.19	....	E. Geissler.
Budweiser	....	2.75	11.34	92.21	3.55	4.24	0.28	....		0.20		Fr. Schwackhoefer.
Grazer	18$\frac{81}{85}$	3.75	14.11	....	4.07	5.97	0.54	...	0.15	0.21	.....	L. Rosler.
Nussdorfer	....	3.75	13.18	90.57	3.85	5.58	0.42	....	0.14	0.22	.....	Fr. Schwackhoefer.
Simmeringer	..	5.00	14.86	89.20	4.06	6.74	0.45	....	0.20	0.21	.....	Fr. Schwackhoefer.
Schwechater	....	4.25	13.25	90.37	3.62	6.01	0.52	....	0.13	0.21		Fr. Schwackhoefer.
Dortmunder Victoria Brauerei	1884	4.75	15.97	90.91	4.52	6.93	0.99	....	0 15	0.228	0.075	J. Skalweit.
Bremer Actienbrauerei	1884	4.00	15.45	.	4.62	6.21	1.11	....	0.142	0.23	0.095	J. Skalweit.
Hamburger Elbschloss	....	....	13.43	90.86	4.30	4.83	....	....	.....	0.24	0.088	B. C. Niederstadt.
Königsberger Schönbuscher	1880	4.50	14.21	90.27	4.48	5.25	0.44	1.04	.....	0.25	.....	E. Schrader.
Kieler, Waldschlösschen	1873	....	14.18	89.66	3.84	6.50	....	....	.....	.....	0 088	Himly.
Berliner-Friedrichshöh	1887	6.00	16.54	....	4.26	8.02	0.56	2.03	.....	0.247	.....	S. Bein.
Hannover, Einbecker	1879	3.50	13.70	90.32	4.02	5.66	....	....	....	0.36	0.075	J. Skalweit.
Dresdener, Felsenkeller	1878	3.50	12.93	90.86	3.79	5.35	....	....	.....	0.20	0.066	E. Geissler & G. Hofmann.
Baseler, Fuglisthal	1869	3.00	12.90	90.82	3.72	5.46	.	1.07	.....	0.20	.....	F. Goppelsroeder.
Speierer, Schwesinger	1878	4.75	14.01	89.69	3.70	6.61	....	....	.....	0.08	.....	Halenke.
Nürnberger, Actien (pale)	1884	4.25	14.85	89.42	4.27	6.31	1.08	....	0.145	0.22	0.103	J. Skalweit.
Erlanger	1875		13.13	90.93	4.06	5.01	....	0.42	.....	0.24	.....	A. Hilger.
Muenchener, Hofbräu	1846	....	14.81	89.21	4.02	6.77	....	0.351	0.202	.....	.....	Walkenroeder.
Muenchener, Hofbräu	1866	3.50	12.69	91.19	3.88	4.93	0.43	....	.....	0.23	.....	C. Lermer.
Muenchener, Löwenbräu	1867	4.75	13.57	90.09	3.61	6.35	1.07	....	.....	.....	.....	C. Praute.
Muenchener, Spatenbräu	1867	4.50	13.07	90.26	3.23	6.61	....	1.38	.....	.....	.....	C. Praute.
Muenchener, Löwenbräu	1888	3.55	14.75	91.19	3.46	5.33	....	2.60	0.223	.....	.....	C. Gottfried and C. Rach.
Muenchener, Leistbräu	1888	3.75	14.62	88.64	3.74	7.66	....	2.39	0.19	.....	.....	C. Gottfried and C. Rach.

COMPOSITION OF VARIOUS BEERS—(Continued).

GERMAN, AUSTRIAN AND BOHEMIAN EXPORT BEERS.	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.	Obtained In.
Pilsener, Bürgerliches Bräuhaus	1883	3.55	.....	89.92	4.60	5.48	....	...	0.18	0.18	0.07	A. Bertschinger.	
Pilsener, Actien Brauhaus	1883	2.75	.....	90.98	4.60	4.42	..	.....	0.144	0.176	0.065	A. Bertschinger.	
Pilsener, Actien Brauhaus	1897	....	12.21	.....	3.82	4.82	....	.....	0.045	.	......	C. Conrad.	Berlin.
Pilsener, Bürgerliches Bräuhaus	1888	3.55	11.95	91.19	3.46	5.33	....	1.047	0.19	.....	......	C. Gottfried and C. Rach.	Munich.
Pilsener, Bürgerliches Bräuhaus	1898	3.80	13.82	.....	4.20	5.70	....	1.18	0.19	.....	......	Bernhold and Karabibarowic.	Munich.
Pilsener, Bürgerliches Bräuhaus	1901	3.43	12.83	.....	3.95	5.25	0.42	1.29	0.099	.....	0.063	Wahl and Henius.	Chicago.
Pilsener, Genossenschafts-Brauerei	1901	4.61	14.29	.....	4.07	6.48	0.52	2.15	0.108	.....	0.0855	Wahl and Henius.	Chicago.
Pilsener, Anton Dreher	1901	2.42	10.80	.....	3.52	4.05	0.34	1.00	0.072	.....	0.050	Wahl and Henius.	Chicago.
Michelober, Dreher	1888	3.80	13.30	90.44	4.11	5.43	...	1.28	0.15	.....	......	C. Gottfried and C. Rach.	Munich.
Kleinschwechat, Dreher	1898	3.95	13.07	.....	3.83	5.67	....	1.51	0.13	.....	....	Bernhold and Karabibarowic.	Munich.
Pilsener	1887	2.20	10.34	92.82	3.28	3.90	0.35	0.79	0.11	0.19	0.05	Wahl and Henius.	Chicago
Schwechater	1876	4.80	.....	90.48	3.52	6.00	0.47	.....	0.13	0.19	......	Fr. Schwackhöfer.	
Liesinger	1876	6.35	.....	87.66	4.66	8.08	0.64	.....	0.23	0.36	......	Fr. Schwackhöfer.	
Thüringer	1898	2.34	.....	.....	3.11	3.74	....	.....	.....	.....	.....	Reinke and Donath.	Berlin.
Thüringer	1895	3.45	12.59	91.17	3.76	5.07	0.41	1.67	0.09	.....	0.08	Wahl and Henius.	Chicago.
Hanover	1898	3.39	.....	.....	3.76	5.05	0.41	.....	.....	0.205	......	Reinke and Donath.	Berlin.
Hanover, Actien Brauhaus	1884	3.75	.....	88.74	5.57	5.53	0.63	....	0.183	0.19	......	J. Skalweit.	
Kieler Actien Brauhaus	1880	....	.....	87.45	4.40	8.15	....	1.56	.....	.....	......	A. Emmerling.	
Hamburger, Kopperhold	1881	....	.....	90.34	4.40	5.26	....	.....	.....	0.29	0.096	B. C. Niederstadt.	
Hamburger	1898	3.27	.....	....	3.43	4.82	....	.....	....	.....	....	Reinke and Donath.	Berlin.
Dresdener Waldschlösschen	1878	3.80	.....	90.31	3.59	6.10	....	.....	0.17	0.28	0.086	J. Skalweit.	
Dresdener Waldschlösschen	1879	4.75	.....	87.71	4.96	7.33	....	....	0.20	0.27	......	E. Geissler and G. Hofmann.	
Nürnberger, Robby	1878	4.50	.....	90.05	3.77	6.18	....	....	0.21	0.22	0.07	J. Skalweit.	
Nürnberger	1898	5.11	.....	.....	3.88	6.8	...	.....	.....	.....	......	Reinke and Donath.	Berlin.
Nürnberger, Tucher	1895	5.15	....	88.62	4.31	7.07	0.51	2.06	0.135	.....	0.095	Wahl and Henius.	Chicago.
Erlanger, Henninger	1884	3.55	.....	90.41	4.61	5.82	1.08	.....	0.148	0.23	0.088	J. Skalweit.	
Brauhaus Würzburg Export Beer	1901	5 35	15.03	.....	4.07	7.22	0.47	2.13	0.099	.....	0.0675	Wahl and Henius.	Chicago.

COMPOSITION OF VARIOUS BEERS—(Continued).

GERMAN, AUSTRIAN AND BOHEMIAN EXPORT BEERS. (Continued.)	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.	Obtained In.
Kulmbacher Actien Brauhaus	1884	6.40	....	85.99	4.31	8.51	1.12	....	0.18	0.32	0.105	J. Skalweit.	
Kulmbacher	1888	7.55	17.60	86.09	4.18	9.71	....	3.11	0.17	....	....	C. Gottfried and C. Rach.	Munich.
Kulmbacher	....	....	16.13	....	4.38	7.84	....	....	0.07	....	....	C. Conrad.	Berlin.
Kulmbacher	1887	4.50	15.30	88.72	4.48	6.80	0.44	1.77	0.24	0.29	0.08	Wahl and Henius.	Chicago.
Muenchener. Löwen Brauhaus	1879	3.60	....	90.14	4.20	5.66	....	....	0.23	0.22	....	E. Geissler and G. Hofmann.	
Muenchener, Löwen Brauhaus	1901	4.13	13.53	....	3.95	5.95	0.44	1.57	0.090	....	0.050	Wahl and Henius.	Chicago.
Muenchener, Spaten Brauhaus	1879	5.05	....	89.67	3.74	6.59	....	....	0.19	0.20	....	E. Geissler and G Hofmann.	
Muenchener, Sedlmayer	1886	4.55	....	88.55	4.90	6.55	....	....	0.18	0.22	0.068	F. Schoffer.	
Muenchener	1898	4.79	....	....	4.16	6.71	....	....	....	....	....	Reinke and Donath.	Berlin.
Muenchener, Pschorr	1885	4.60	....	89.55	4.00	6.45		....	0.14	0.186	0.062	L. Friedrich.	
Muenchener, Salvator	1897		18.80	....	4.61	10.25	....	....	0.09	....	....	C. Conrad.	Berlin.
Muenchener, Pschorr	1895	6.12	....	....	3.47	7.61	0.46	2.69	0.108	....	0.08	Wahl and Henius.	Chicago.
Muenchener, Pschorr	1897	....	14.00	....	3.71	6.82	....	....	0.045	....	....	C. Conrad.	Berlin.
Muenchener, Pschorr Bräu	1901	4.40	13.26	....	3.72	6.12	0.41	1.72	0.072	....	0.054	Wahl and Henius.	Chicago.
BOCK BEERS.													
Budapester	1884	5.55	....	88.55	4.19	7.26	....	....	0.211	0.284	0.88	S. Fischer.	
Brünner.	1876	4.40	....	89.50	4.39	6.11	....	....	0.19	0.27	....	Fr. Schwackhöfer.	
Kieler Actien	1884	1.05	....	90.32	4.03	5.78	....	....	....	....	....	C. G. Zetterlund.	
Dresdener Feldschlösschen	1879	4.50	....	89.01	4.34	6.65	....	....	0.14	0.21	....	E. Geissler and G. Hofmann.	
Hamburger, Kopperhold	....	....	....	88.41	5.30	6.29	....	....	....	0.32	0.109	B. C. Niederstadt.	
Schwechater	1876	4.25	....	90.29	3.83	5.88	....	....		0.14	0.21	Fr. Schwackhöfer.	
Einbecker Bock	1878	5.20	....	87.20	5.39	7.41	....	....	0.15	0.34	0.085	J. Skalweit.	
Einbecker Bock Export	1893	....	15.58	....	3.76	8.04	....	....	0.138	0.248	0.08	B. C. Niederstadt.	
Muenchener, Hofbräu (Einbock)	1879	8.49	....	83.70	4.75	11.60	....	....	....	0.24	0.39	E. Geissler and G. Hofmann.	
Muenchener, Spaten	....	8.47	....	82.65	7.00	10.35	0.71	1.02	....	....	....	Aubry.	
Uelzener Bock Export	1878	5.25	18.23	86.85	5.08	8.07			0.22	0.26	0.095	J. Skalweit.	
Bremer Doppelt Lager	1878	1.01	23.28	85.92	9.20	4.88	....	....	....	0.21	0.082	L. Janke.	
Kulmbach Actien	1880	6.97	20 24	85.04	5.28	9.68		....	....	0.15	0.35	E. Geissler and G. Hofmann	

COMPOSITION OF VARIOUS BEERS—(Continued).

GERMAN TOP FERMENTATION BEERS.	Time of Analysis	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.
WEISSBEERS.												
Hannover Städtisch	1878	7.20	9.44	91.64	1.08	7.28	....	....	0.18	0.18	0.05	J. Skalweit.
Hamburger Weissbier Br	1884	2.45	8.30	93.78	2.38	3.54	0.62	....	0.578	0.098	0.022	J. Skalweit.
Muenchener v. Schramm	1888	4.05	13.23	90.52	3.75	5.73	0.35	2.04	0.149	0.143	....	J. Skalweit.
Berliner Actien Br	1887	4.95	5.77	95.17	0.94	3.89	....	0.49	0.363	0.186	0.15	S. Bein.
Berliner G	1895	2.94	10.0	....	2.91	4.30	....	....	....	....	....	O. Reinke, Woch'schrift, xii. 32
Berliner Export B	1895	2.54	10.88	....	3.52	4.02	....	....	....	....	....	O. Reinke, Woch'schrift, xii 32
Berlin	1895	1.85	10.26	....	3.53	3.35	....	....	....	....	....	O. Reinke, Woch'schrift, xii. 32
Provinz B	1895	2.36	8.44	....	2.48	3.56	....	....	....	....	....	O. Reinke, Woch'schrift, xii. 32
Muenchener v. Schramm Weissbeer-Bock	1888	6.85	17.94	86.55	4.49	8.96	0.59	3.65	0.18	0.228	....	E. Wein.
Lichtenhainer	1886	4.25	9.26	93.76	3.0	3.22	....	0.66	0.238	0.128	....	J. Herz.
Lichtenhainer	1898	....	7.89	....	2.43	3.08	....	....	0.207	....	....	C. Conrad, Berlin.
OTHER TOP-FERMENTATION BEERS AND MALT EXTRACTS.												
Broyhan:												
Hannover Stådt. Br.: Einfacher	1884	5.75	7.95	....	0.82	6.31	1.32	....	0.158	0.20	0.054	J. Skalweit.
Hannover Städt. Br.: Doppelter	....	....	13.22	....	0.96	11.30	1.67	....	0.06	0.23	0.123	J. Skalweit.
Münster Altbier: Von Appels.	1883	1.30	12.25	92.19	4.45	3.35	0.33	0.58	0.372	0.294	0.052	König and Schwarz.
Münster Von Brüggemann	1883	3.00	12.67	91.08	3.87	4.93	0.52	0.72	0.444	0.306	0.055	König and Schwarz.
Dortmunder Adambier	1889	0.23	18.13	....	7.38	3.37	0.70	0.66	0.62	0.284	0.133	O. Reinke, Wochenschrift, 1889.
Dortmunder Adambier, 33 years old	1897	....	26.4	....	7.35	13.38	0.66	3.61	0.36	0.43	0.158	C. Conrad.
Chemnitz Städt. Br.	1878	3.10	7.95	93.84	1.92	4.11	1.06	....	....	0.11	0.94	C. Hebenstreit.
Braunschweiger Mumme	....	44.7	54.80	49.80	3.60	47.60	....	....	....	....	....	Kayser.
German Malt Tonics	1880	....	61.63	70.69	2.32	56.99	....	....	....	1.39	0.509	B. C. Niederstadt.
Braunschweiger Doppelschiffs Mumme. F. Steger	1899	....	....	47.74	....	52.26	3.06	40.39	0.36	1.35	0.40	Aufrecht.
Joh. Hoffs' Malzgesundheitsbier	1892	....	16.98	....	4.12	8.27	....	1.90	....	0.222	0.112	B. C. Niederstadt.
M. Hoffs' Malz Extract Hamburg	1892	....	16.53	....	3.12	10.72	....	1.99	....	0.248	0.084	B. C. Niederstadt.
Diätischer Malz-Extract of Gron and Raudwitz Vienna	1888	8.5	17.42	87.74	5.16	7.10	0.47	....	0.27	0.19	0.073	L. Rösler.
Condensed Pale Ale	1887	10.3	73.34	52.29	25.62	22.10	2.95	3.61	0.475	1.047	0.322	Lendtner and Trillich.

COMPOSITION OF VARIOUS BEERS—(Concluded).

MISCELLANEOUS FOREIGN BEERS.	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By	Obtained In
BELGIAN BEERS: Lambic	1839	2.87	21.19	86.58	7.77	5.65	....	1.06	1.11	....	....	Krandauer.	
Faro	....	3.25	13.81	90.52	4.33	5.15	....	0.71	0.90	.. ..	....	Krandauer.	
Lambic	1871	2.25	17.24	89.14	6.38	4.48	....	0.66	1.06	.. ..	....	Krandauer.	
FRENCH LAGER BEERS:													
Average of 67 samples	....	.....	12.40	91.14	3.54	5.32	....	1.11	0.19	....	....	Ch. Girard.	Paris.
Tantouville Lager		.....	15.58	89.21	4.79	6.00	....	....	....	....	....	Ch. Girard.	
Lille Lager	....		12.00	91.35	3.35	5.30	....	....	....	0.35	....	Ch. Girard.	
SPANISH BEERS: Bedika de la Cruz													
Blanka Imp. Bock Ale	1884	1.70	16.90	89.03	6.33	4.24	....	0.93	0.19	....	..	Zetterlund.	
Blanka Imp. Double Bock	1884	3.55	16.07	87.99	4.38	7.31	...	0.89	0.07	....	....	Zetterlund.	
Blanka Imp. Specialidade	1884	3.25	13.42	90.25	4.31	4.80	....	0.84	0.24	....	....	Zetterlund.	
HOLLAND: Amsterdam Balkerbeer	1874	2.25	12.47	.....	3.20	6.07	0.52	0.96	.....	0.25	....	Krandauer.	
Amsterdam Amstelbeer	1884	5.37	15.27	83.67	3.94	7.39	....	....	0.28	....	....	Zetterlund.	
Haarlem Ale	1884	0.85	11.90	92.80	4.50	2.90	....	....	0.31	....	....	Zetterlund.	
Haarlem Stout	1884	3.90	14.31	90.07	4.19	5.93	....	....	....	....	....	Zetterlund.	
SWEDEN: Stockholm Export	1871	.....	14.10	90.40	4.50	5.10	....	....	....	....	....	Aug. Almèn.	
Göteborg	1879	3.37	14.11	90.18	4.39	5.33	...	.. ..	....	....	....	Aug. Almèn.	
Upsala Export	1879	8.82	18.15	85.64	3.79	10.57	....	....	....	....	....	Aug. Almèn.	
Oerebro Swedish Beer	1880	10.64	13.79	87.30	1.09	11.61	....	....	0.108	....	....	Oerebro Scient. Station.	
Oerebro Dünn Beer	1880	4.60	8.09	93.03	1.72	4.65	...	....	0.126	....		Oerebro Scient. Station.	
NORWAY: Christiania Pale Ale	1884	5.30	15.94	88.27	4.57	6.80	0.89	....	0.11	....	....	C. G. Zetterlund.	
Drammen, Salvator	1884	5.70	16.94	87.03	4.94	7.06	....	....	0.09	....	....	C. G. Zetterlund.	
DENMARK: Gamle Carlsberg Lager-beer	....	.....	13.90	90.4	4.30	5.3	0.37	1.21	.....	0.208	....	Gamle Carlsberg Laboratory.	Copenhagen.
Gamle Carlsberg Maerz or Bock	....	.....	14.80	88.8	3.6	7.6	....	....	.....	.. ..	....	Gamle Carlsberg Laboratory.	Copenhagen.
JAPAN: Asahi	1897	.....	14.44	....	4.60	5.64	....	1.72	0.133	0.214	0.07	A. Lang.	
Kirin	18 98/99	.....	13.0	.....	3.9	5.37	....	....	.....	.....	....	Doemens.	
Sapporo	....	.....	14.2	.. ...	4.01	6.47	....	....	.....	.....	....	According to K. Yagi.	

BREWING LOSSES FROM MALT MILL TO PLATFORM.

Brewing operations cannot be carried out in such a way as to deliver all of the valuable substances contained in, or derived from, the brewing materials into the packages that are placed on the platform of the brewery for delivery to the market, but the operations should be so conducted as to reduce the amount of valuable substances lost, to a minimum.

These losses are manifold and occur with almost every operation and every transfer of goods. They may be considered in the following order:

Loss from scouring;
Loss from malt hopper to mash-tun;
Loss from material gathering under false bottom (underdough);
Loss from incomplete gelatinization or inversion of starch;
Loss from incomplete inversion of albumen;
Loss from incomplete extraction of the grains;
Loss from boiling of wort with hops;
Loss from incomplete extraction of spent hops;
Loss from transfer of wort from kettle to settling tank;
Loss from incomplete extraction of the sediment ("Trub");
Loss during fermentation and storage;
Loss from finings, chips, filtration and racking;
Loss from racking bench to platform.

SHRINKAGE IN VOLUME FROM KETTLE TO STARTING TUB.

Besides these *real losses* there are *apparent losses*, owing to a shrinkage in volume unaccompanied by the loss of any valuable substances. Such shrinkages are taken notice of as significant only between kettle and starting tub, viz.:

Shrinkage of wort due to contraction by cooling from 212° F. in kettle to 43° to 48° F. (5° to 7° R.) in settling tank, approximately 4½ per cent.

Shrinkage due to evaporation on surface and Baudelot coolers (see "Cooling"), approximately 5 per cent.

Besides this apparent loss there is to be added the shrinkage due to a real loss, occasioned by:

Adhesion of wort to vessels like kettle, hop-jack, surface and Baudelot coolers, pumps and pipes, about ½ per cent.

Volume of spent hops and wort adhering is about two and one-half barrels per 100 pounds of hops, according to repeated tests made by M. Henius, or per 100 barrels of wort if 100 pounds are used, 2½ per cent.

Total shrinkage if hops are not sparged, and one pound of hops is used per barrel, 12½ per cent.

If hops are sparged the shrinkage is reduced by the number of barrels of water used for sparging, or, if five barrels are used per 100 pounds of hops, the total shrinkage would be 7½ per cent, or from 100 barrels of wort leaving the kettle 92½ would reach the settling tank.

Where less hops than one pound per barrel are used the total shrinkage may be readily calculated from above figures.

Example.—What is the total shrinkage if 70 pounds of hops per 100 barrels are employed?

Solution.—70 pounds of hops retain $\frac{2.50 \times 70}{100} = 1\frac{3}{4}$ barrels of wort.

Therefore total shrinkage, if hops are not sparged, is per 100 barrels of wort $10 + 1\frac{3}{4} = 11\frac{3}{4}$ barrels.

And if hops are sparged with three and one-half barrels of water the total shrinkage will be $11\frac{3}{4} - 3\frac{1}{2} = 8\frac{1}{4}$ barrels.

The only uncertain quantity in the above calculations is the amount of evaporation, which may vary considerably according to atmospheric conditions, system of cooling, etc. (See "Cooling.") It was found in one case by R. Wahl, where an atomizer was employed, to reach 10 per cent. Under ordinary circumstances it is safe to take 5 per cent as an average, if surface and Baudelot coolers are employed.

LOSS FROM SCOURING.

Malt is delivered to the brewer freed from sprouts, but is often passed through a cleaner, or scourer, before crushing, whereby ½ to 1 per cent more of substance is removed in the form of adhering rootlets, pieces of husk, etc. Such dust, according to Doemens, contained, on the average of seven tests, 23 per cent of extractive substances. Loss, through scouring 10,000 pounds of malt, would be 10 to 20 pounds of extract.

LOSS FROM MALT HOPPER TO MASH-TUN.

The loss from malt hopper to mash-tun, occasioned mainly by escaping malt dust in its transfer from crusher to tun, should be insignificant, but may amount to considerable if the malt dust finds easy egress through crevices or untight joints.

LOSS FROM FORMATION OF UNDERDOUGH.

This loss may be considerable if the mash-tun is of faulty construction, or mashing is carelessly done, at times the entire space under the false bottom being filled with underdough. For conditions favoring the accumulation of underdough see "Mashing Operations" and "Straining of Wort," also "Brewing Outfit."

This underdough contains a considerable amount of extract-yielding substances, and at times it may be composed mainly of finely divided starch that finds its way through the perforations of the false bottom. The weight of this underdough was determined in a case where all precautions were used to avoid its formation, and the mash-tun was of proper construction, and found to be 200 pounds wet, with .15 per cent of extract and 75 per cent of water. The weight of brewing material was 7,200 pounds of malt and 6,700 pounds of grits. Therefore:

Loss from formation of underdough from 10,000 pounds of material was about 22 pounds of extract, or 0.22 per cent.

The Brauerkalender of 1900, page 85, states that in a similar test made in a brewery on a large scale, the amount of underdough was found to be 70 pounds from 10,000 pounds of material, and contained 50 pounds of extract, a loss amounting, therefore, to ½ per cent.

These two cases probably represent the extremes and prove how difficult it is to obtain absolutely reliable results as to the quantity of underdough formed.

ANALYSIS OF AN UNDERDOUGH (BY WAHL AND HENIUS).

	Per cent.
Moisture	75.00
Dry substance	25.00
Extract in water-free substance	62.53
Of this there was soluble	22.63
Albumen in dry substance	34.88
Insoluble extractive matters	2.90
The Balling of the water filtered from the underdough was	7.30

LOSS FROM INCOMPLETE GELATINIZATION OF STARCH.

This loss may be considered together with the losses through incomplete extraction of grains.

The amount of loss from these two sources is usually determined together, and represents the extract that remains in the grains and is consequently lost for brewing purposes.

The amount of such extract varies from 5 to 10 per cent of the weight of the dry grains if the material is properly treated, and from 10 to 20 per cent if proper precautions are not used in mashing.

It is not at all unusual to find grains that contain 20 per cent of extract in the dry substance, which means a considerable loss.

We may take it that the ordinary brewing material will yield about 25 per cent of absolutely dry grains. Therefore, 20 per cent of extract in these dry grains would mean a loss of five pounds per 100 pounds, or a loss of 500 pounds for a brewing of 10,000 pounds of material. This loss can be reduced, by introducing scientific mashing methods, to about 1½ to 2 per cent, or 150 to 200 pounds per 10,000 pounds of material. This still means a loss of about four to five barrels of beer of 13 per cent Balling, whereas an amount of extract left in grains, of 20 per cent of the weight of the dry grains would mean a loss of about 15 barrels per 10,000 pounds of material.

An analysis of the grains is, therefore, a very simple and efficient means of determining the extent of one of the most prolific sources of loss in the brewery.

The amount of soluble extract in grains, due to imperfect sparging, can be readily determined by pressing the water from an average sample of grains taken from the grains box or pile, and weighing this water with a saccharometer. The weight indicated by the saccharometer in degrees gives approximately the percentage of loss. Thus, an indication of 2 per cent would mean a loss of two pounds of extract for every 100 pounds of material, or 200 pounds for every 10,000 pounds of material, or about five barrels of beer of 13 per cent Balling.

Grains taken from a brewing that was properly made gave the following results:

	Per cent.
Moisture	81.6
Extract in water pressed from grains	0.7
The dried grains contained:	
Moisture	6.5
Oil	7.53
Albumen	33.75
Raw fiber	16.44
Ash	3.47
Extractive substance (starch, sugar, etc.)	7.50
Of which there was soluble (sugar, etc.)	3.08
Insoluble extractive matters (starch)	4.42

These grains were obtained from a brewing of 10,650 pounds of malt and 10,000 pounds of grits, or 20,650 pounds of material, and were dried in a grains drier. The total weight was 4.515 pounds, or 22 per cent of the weight of the material, while the weight of the wet grains was 24,538 pounds, or 119 per cent, or 19 per cent more than the weight of the materials.

LOSS FROM INCOMPLETE INVERSION OF ALBUMEN.

The albumen of malt is only partly inverted in the mash-tun, and approximately one-half of it goes into the grains while practically all of the albumen of unmalted cereals passes into the grains. More albumen will, however, pass into the wort if the mash is well peptonized, and the yield will be correspondingly higher than if this does not take place.

Two worts made from the same malt, but resulting from mashes, one of which was well peptonized, the other poorly peptonized, were found to contain 0.95 per cent, and 0.6 per cent, respectively, of albumen (see page 730); or, for 100 pounds of material, a loss of 1.8 pounds of albumen, or, for 10,000 pounds of material, 180 pounds of albumen. Considering the importance of albuminoids in point of palate-fulness and foam-holding capacity for the finished product, the loss of extract in this case becomes doubly significant.

LOSS FROM BOILING WORT WITH HOPS.

Here we encounter a loss in the essential oil of hops, which passes off freely with the vapors from boiling wort. This loss cannot be weighed. It has an important bearing on the hop aroma of the finished product, and the hops must be treated with this point in view. (See "Boiling Operations," p. 726.)

LOSS FROM INCOMPLETE EXTRACTION OF HOPS.

In some breweries the hops are not sparged with water at all, and the entire amount of wort held by them is lost. This amount is about equal to six times the weight of hops employed. Hence, 100 pounds of hops would retain 600 pounds of wort, and if this was 13 per cent Ball. the loss would be 78 pounds of extract, or about two barrels of wort, or for 10,000 pounds of material that yield about 190 barrels of wort, for which 200 pounds of hops may have been employed, there would result a loss of 156 pounds of extract, or about four barrels of wort.

In case the hops are sparged in the usual manner in the hop-jack, this loss is, of course, considerably reduced. It was found to be 40½ pounds where 13 barrels of water were used to sparge 260 pounds of hops, or 15 pounds per 100 pounds of hops. The weight of the wet hops from 250 pounds was found to be 1,690 pounds, and the saccharometer indication of the hop-liquid was 2.4 per cent.

LOSS BY TRANSFER OF WORT FROM KETTLE TO SETTLING TANK.

This loss is difficult to ascertain, and may be estimated as approximately ½ per cent. Thus, the loss from 10,000 pounds of material, from this source, would be about 50 pounds.

LOSS FROM INCOMPLETE EXTRACTION OF "TRUB" (DREGS, SEDIMENT).

The proteids precipitated by boiling the wort are quite voluminous. In American brewing operations they are separated from the wort in the starting tub, partly rising to the surface when fermentation begins, and forming the dark cover or scum which, when the beer is drawn off to the fermenting vat, is usually allowed to sink with the receding surface and to join with the sediment of the same nature. This "Trub," as it is called in German, retains quite a large amount of wort, which, according to experiments made by Lermer, approximated 2 per cent of the

total wort. This "Trub" should be collected in so-called sediment bags and allowed to drain, thus reducing, if properly done, the loss to about one-half to three-quarters barrel per 100 barrels, or about 300 to 400 pounds of wort per 10,000 pounds of malt, or about 40 to 60 pounds of extract per 10,000 pounds of malt. If no sediment bags are used, the loss may amount to about four barrels, or about 120 pounds of extract. The "Trub" from pure malt worts is much larger than from worts produced with the aid of unmalted cereals, when above figures may be reduced by a percentage equal to that of unmalted cereals employed, or the loss will be about one-quarter to one-half barrel for 30 to 40 per cent of unmalted cereals per 100 barrels, or about ¼ to ½ per cent.

The sediment bags should be washed with hot water after using, and from time to time boiled or steamed out. An addition of bisulphite of lime to the washing water from time to time aids in keeping them from souring or putridity.

LOSSES DURING FERMENTATION AND STORAGE.

During fermentation there is some evaporation; the sugar ferments to alcohol and carbonic acid, most of which escapes; part of the albuminoids and mineral substances of the wort are used up to nourish the yeast, and there is some waste from skimming off the covers, like hop-resin cover and final cover.

From the fermentation of so much sugar and the escape of carbonic acid gas incidental thereto, one should imagine that a contraction in volume took place during fermentation on this account. This, however, is not the case. A. L. Stern (Journ. Chem. Soc., through Am. Br. R., XIII, p. 414) found that the volume of a sugar solution is the same before and after fermentation, if no evaporation of water takes place. The deduction is that the expansion of the alcohol formed equalizes the contraction due to the removal of the sugar.

The loss during fermentation is not so great on this account as it otherwise would be. The loss due to the settling of yeast is approximately ½ per cent, and to evaporation, skimming and transfer, about 1 per cent, or, a total of about 1½ per cent.

During storage these losses continue in a measure, but the loss from evaporation is not so great. About ¼ to ½ per cent will cover the loss from yeast sedimentation and transfer mainly, so that the total loss from settling tank to chip-cask is about 2¼ per cent.

LOSSES FROM FININGS, CHIPS, FILTRATION AND RACKING.

In the chip-cask the loss becomes quite considerable, especially if no filter is used, on account of the absorption of a quantity of beer by the chips, and the sediment of finings and yeast clinging to them. Some water being used in the preparation of the finings, and the chips going into the cask soaked with water, the loss in volume is somewhat reduced, but the loss in extract or beer is equivalent, of course, to the quantity removed with chips and finings.

It was found that the amount of beer removed by 6,189 straight chips that were used in a 60-barrel cask, was 213 pounds, or, about 1¼ barrel per 100 barrels, or, about 80 pounds of original extract was removed with the chips per 10,000 pounds of material employed, without thereby decreasing the volume, since the beer simply displaced so much water in chips. The total losses in volume due to treatment in chip-cask, transfer to racking bench and filtration are estimated at about 1 per cent. They are less than formerly when no filter was used. Since the introduction of the filter less isinglass is employed and also less chips, reducing the actual loss considerably.

LOSSES FROM RACKING BENCH TO PLATFORM.

To these losses must be added the amount of beer served at the "Sternewirth" to working men and visitors, and which, of course, varies materially with the custom and output; ¼ per cent may be considered a fair amount for a large brewery, 1 per cent for a small brewery.

TOTAL SHRINKAGE.

Shrinkage in settling tank	¼ to ½	per cent
Shrinkage during fermentation	1½	per cent
Shrinkage during storage	¼ to ½	per cent
Shrinkage in chip-cask and to racking bench	1	per cent
Shrinkage from racking bench to platform	¼ to 1	per cent
Total shrinkage for a large brewery from settling tank to platform	3½	per cent

Since 100 barrels of wort in the kettle give 92½ barrels in the settling tank, if the hops are properly sparged, and 100 barrels in the settling tank yield 96½ barrels at the racking bench.

One hundred barrels of wort run out of the kettle should give about 89 barrels of beer at the racking bench.

$$\frac{92\tfrac{1}{2} \times 96\tfrac{1}{2}}{100} = 89+.$$

One hundred and twelve barrels of wort run out of the kettle should give 100 barrels of beer at the racking bench

$$\frac{100 \times 100}{96\tfrac{1}{2} \times 92.5} = 112.$$

Where the brewery cooperage is quite small, this loss is increased. If hops are not sparged, the loss is 2 to 4 per cent higher.

Excise regulations demand the entry of the number of barrels of finished beer obtained from each brew, and not the number of barrels of wort obtained in the cellar. It is, therefore, necessary to make the proper deduction from the amount of beer in the kettle or from the amount obtained in the settling tank, before making the entries. The above figures will serve as a guide in this respect. Notice should be taken that where the hops are not sparged the reduction is several per cent greater, according to the amount of hops used and the amount of sparging water employed.

TREATMENT AND PROTECTION OF SURFACES.

The treatment of the different surfaces in the brewery can be classified as follows:

1. Cleaning operations.
2. Varnishing wooden brewery vessels.
3. Varnishing, lacquering and staining iron vessels.
4. Pitching wooden casks, kegs and barrels.
5. Covering surfaces for ornamental as well as protective purposes, such as painting, calcimining, whitewashing and varnishing.

CLEANING OPERATIONS.

These comprise:

Cleaning or scouring of floors, walls, ceilings, inside and outside of vessels, tubs, casks, conduits or pipes, and the removal of waste products.

The importance of cleanliness in every department of the brewery cannot be too emphatically impressed upon the brewer, especially the cleaning of vessels containing wort and beer, and the surroundings that can affect these.

As remnants of wort or beer, when exposed to the air, soon become breeding places for germs and micro-organisms which are always present in the air, any vessel that has been emptied should be cleaned as soon as possible, for the longer these remnants are allowed to remain, the more they dry by evaporation, and the more difficult it is to remove them. (See "Micro-organisms.")

The readiness with which a surface can be cleaned depends mainly upon the porosity of the material and the smoothness of its surface. Wood construction for floors, walls, beams, posts, cask supports, etc., being replaced in modern construction and outfits more and more by tiling, cement and asphalt, cleanliness is facilitated in proportion.

On hard and smooth impervious surfaces any impurities or foreign matters merely adhere, and can be readily removed, but on a substance of a porous nature these impurities, especially if they are liquid, will sink into the pores from which they can be removed only by tedious and lengthy operations of cleaning or scouring.

As aids and accelerators to the brush and hose in the different cleaning operations, various substances may be used that may be classified as antiseptics, solvents, corrosives and abrasives.

ANTISEPTICS.

Before mentioning the various antiseptics employed in the brewery, attention should be called to the danger that can arise from their improper use.

Caution.—Wort and beer are very sensitive substances, and readily take up foreign odors and flavors. Therefore, the brewer should well consider, before he uses any chemical, whether it can impart any flavor or odor, and also reflect upon the proximity of any open vessels containing wort or beer that might be affected. Furthermore the ventilation of the room in which these chemicals are employed must be taken into account.

The chemicals generally used are the following:

Lime or milk of lime is the most universal and at the same time one of the cheapest and safest antiseptics now in use, and is most effective when freshly prepared. It is made by slaking ordinary builders' lime, that is, by placing the lime in a shallow vessel and pouring over it one-half to three-fourths its weight of water. In a short time the lime becomes heated, emits vapors of water, swells up and finally crumbles to a white powder.

This powder, or slaked lime, is then stirred in water to a creamy consistency and the mixture passed through a fine sieve, in order to remove the particles of limestone always present, whereupon it is ready for use.

This milk of lime can be used anywhere in the brewery, except upon the ceilings over open fermenting vats, since the lime, if used there, might drop into the wort or beer.

Chloride of lime, bleaching powder, chlorinated lime, calcium hypochlorite, as it is variously designated, made by saturating slaked lime with chlorine gas, is a cheap and powerful antiseptic, but *should not be used in cellars* as its effectiveness depends upon the action of the liberated chlorine, which has a penetrating, disagreeable odor.

Chloride of lime can be used in the malt house, wash house, stables, in fact, in any place not containing wort or beer or near enough thereto to affect it.

Bisulphite of lime, a liquid made by saturating a thin milk of lime with sulphurous acid gas, or sulphur dioxide, has also found an extended use in breweries, in fact, it ranks second to milk of lime in popularity. It emits a pungent odor of burning sulphur when in a concentrated state, but when diluted can be safely used in the same manner as milk of lime.

Acid fluoride of ammonia, or "antiseptic salt," is also very effective as an antiseptic agent. It attacks metal and glass strongly, One pound dissolved in 30 gallons of water can be used in place of bisulphite of lime of ordinary strength.

Antinonnin is a creosote derivative, made in Germany, and introduced into this country with good success. The method of application is not complicated, and since the product is used in a greatly diluted state, which adds cheapness to its commendable properties, it can be considered a good parasiticide and disinfectant for brewery use.

Antinonnin can be used with water or whitewash; the latter is perhaps preferable. (See "Whitewashing.")

Formalin has of late become a much used and effective antiseptic agent in packing houses and other industries, and is being recommended for brewery use in Germany, having, however, found little application, if any, in American breweries.

Formalin consists of a 40 per cent solution of formaldehyde in water and, in its concentrated state, has an irritating, pungent odor. It is a powerful antiseptic, more so than bisulphite of lime, which it resembles in many ways, excepting that it is more costly.

Commercial formalin should be diluted before use to such an extent that the odor of formaldehyde is faintly perceptible above the vessel containing it (diluted about 1-1000). As there are at present no reliable data at hand as to the effect of formaldehyde, if absorbed by wort or beer, great circumspection should be used in employing formalin in fermenting cellars or poorly ventilated rooms.

Permanganate of potassium, or a solution of this salt, is one of the most powerful antiseptics and oxidizing agents known.

It will, however, not find an extended application for treating large surfaces in the brewery on account of its great cost.

It forms with water a purple solution, which has neither odor nor pronounced taste and can, therefore, be used in every department of the brewery. Its principal effectiveness is in purifying or removing concentrated or neglected results of uncleanliness, such as in stables, urinals or catch-basins of sewers. To be most effective for these purposes the solutions should be made slightly alkaline by an addition of a small amount of caustic potash or soda.

SOLVENTS.

Carbonate of soda, either in the form of soda crystals and then ordinarily termed "soda," or in the form of a powder and then termed "soda ash," or "calcined soda," which is more effective than the crystal form, is especially effective in cleansing operations where organic substances are to be removed, on which it acts as a solvent, for instance:

Incrustations in vessels, like kettle or surface cooler, cooler pan, pipes, pumps, on attemperators, or remnants in bottles which are treated with a solution containing from 1 to 5 per cent of soda, according to circumstances.

Softening coatings of shellac or pitch, the precaution being used, however, not to dissolve the coating entirely if the vessel is to be recoated since the soda would penetrate the wood and create difficulties in revarnishing or pitching.

Dissolving resins and other organic matter from wood. It is therefore useful in treating ale packages and chips.

Caustic soda, or soda lye, is still more effective than soda ash, and is used hot for cleansing pipes, five to ten pounds per barrel of water being employed.

Ammonia. A solution of ammonia mixed with whiting or chalk, as a distributor, gives good results for cleaning and polishing copper and brass.

CORROSIVE SUBSTANCES OR ACIDS.

Sulphuric acid and *muriatic acid,* properly diluted, are often used in connection with some abrasive substance like emery or pumice stone, or some distributing material, than which there is none more effective than fresh yeast. The acids aid in cleansing by dissolving the oxides of the metals that have formed by contact with air, like iron rust or verdigris.

ABRASIVE SUBSTANCES.

Emery is a grayish-brown crystalline substance, possessing great hardness, and is therefore used as a grinding and polishing material. It comes on the market in different degrees of fineness so as to be used for various purposes. Emery is used almost entirely upon rough metallic surfaces, but should not be used on smooth polished metals, being too gritty and causing scratches.

Pumice Stone is a gray, porous stone found in the neighborhood of volcanoes. It is very porous, similar to coke, and is used as an abrasive similar to emery, being, however, better adapted to smooth metals, as it is not so hard or gritty as as emery.

Infusorial Earth, or Kieselguhr, is a chalk-like substance consisting of the skeletons of diatoms. It is of a siliceous character and on account of its comparative softness can be used on smooth surfaces.

Sand or Cinders. For scouring metals the hairs of a brush are too soft to be of much effectiveness, and for this purpose sand is used in connection with them. The sand for this purpose should be clean, that is, not mixed with clay or other soft and smooth substances.

Cinders are in universal use because they are always at hand, but before use should be sifted and only the finer particles used.

Proprietary cleaners now on the market, usually sold in tin boxes or cans, consist mostly of different abrasive materials, such as emery, tripoli, rotten stone, crocus or rough mixed to a paste with some fat or wax or, if liquid, with gasoline or oil as a vehicle for spreading. These cleaners are usually intended for nickel, copper and brass, for which purpose they generally give good results.

CLEANING OF BREWERY FLOORS, WALLS, VESSELS AND UTENSILS.

MILL AND BREW HOUSE.

Mill House Floors. Sweeping the floors with wet sawdust readily takes up the flour and dust adhering to it.

Malt Mill. Cleaning the malt mill is an easy operation if it is kept dry. All that is then necessary is to use a stiff brush and scraper for the corners and crevices. When there is a stationary connection between mill and mash-tun it happens frequently that

the slide in the spout was not closed after the discharge of the ground malt, causing the vapors from the mash to find their way into the malt mill, moistening and softening the malt flour retained therein. In such a case nothing but a thorough cleaning of the mill, after taking it apart, will answer.

Brew House. The walls and ceiling should be kept in proper cleanly condition, the frequency of washing depending upon the finish of their surfaces. (See "Painting, Whitewashing, Etc.")

The floors around the cooker, mash tub, kettle, etc., should be thoroughly scrubbed with water and broom after each brewing, provided the floors are of waterproof construction and have the proper drainage.

When washing wooden floors the addition of bisulphite of lime is advisable.

Hot water tanks are subject to the same trouble as boilers, namely, deposits of scale or incrustation of lime salts upon their inner surfaces, but to a less extent. If cleaned regularly with a steel wire brush they can readily be kept clean, but if neglected, require the same chipping and scraping as does a boiler.

Cold water tanks accumulate a slimy coating which can be readily removed by using a bristle brush, together with sand or cinders.

Cooker, pressure cooker, mash tub, hop-jack and surface cooler or beer tank should be cleaned as soon as possible after they are emptied in order to prevent souring of their contents. (See also "Varnishing and Staining Iron Vessels.")

They should be cooled before cleaning, and a man, working in a normal temperature, can do many times the amount of work he can do in a superheated one. This cooling is readily accomplished by spraying the inside walls and bottoms with cold water from a hose—in the mash tub and hop-jack running cold water through the over-sprinkler or sparger—whereby the vessels and contained air are quickly cooled.

The cooker and pressure cooker are readily cleaned by means of a brush and stream of water from a hose, the remnants of brewing materials being easily flushed through the sewer opening.

In the mash tub, cleaning is a more laborious operation. After the grains are thrown out by the machine, or by hand shovel, the false bottom or strainer is sprinkled with cold water and then the clamps unscrewed and the segments removed. It is then usually found that the real bottom is covered with a considerable amount of what is styled "underdough," a pasty mass with considerable adhesion to the tub bottom. This mass must be thoroughly and completely removed, since it consists largely of starch and albuminoids especially prone to decay and putrefaction. This underdough requires for its removal a most energetic application of water spray, both hot and cold, and of the action of a brush or broom.

This same procedure also applies to the hop-jack.

The segments of the false bottom or strainer are then washed and scrubbed, and attention is here called to an extra manipulation not generally carried out. It is well to hold each of these false bottom segments against the light in order to see if all the holes are open, and if any are clogged up, to remove the obstructions with a wire or pin before relaying the bottom for the next brewing. It requires no explanation that as the holes become stopped up the running of the wort and extraction of the grains must become correspondingly sluggish.

If the inner surfaces of these vessels become crusted or coated with solid particles from the wort, which should not happen if regularly cleaned, such matters can be removed by scraping or with a steel wire brush and sand. After such treatment such vessels as were varnished should be revarnished.

Brew Kettle. In cleaning the kettle the neck should always be cleaned before the kettle proper. For this purpose a ladder is placed upon a scaffolding in the kettle, barely reaching into the opening of the neck.

For cleaning the kettle the brewer has a good agent which costs him nothing, by taking the beer yeast, of which about three gallons are mixed in a wooden bucket with about two gallons of finely screened light ashes or cinders. After the mass has been well mixed about one to one and one-half fluid ounce of commercial sulphuric acid or oil of vitriol should be added, and the mixture be again stirred thoroughly. An excess of acid will attack the copper too much and cause it to turn blue and lose its lustre.

After the entire upper part of the kettle has been rubbed bright, the yeast mixture is washed off with water and brooms and the whole surface spread over with a mixture of yeast and a small amount of ashes, but without any acid, a fresh or washed

broom to spread the preparation being used, and the entire upper part once more rubbed down thoroughly. The yeast mixture is then left on the walls, the scaffolding removed from the kettle and the bottom part of the kettle treated in the same manner as the upper, that is, first treated with the thick yeast mixture with acid and afterward with the thin mass without acid. Finally, the mixture of yeast and ashes is scrubbed from the walls with water and brooms, and the vessel well rinsed with clear water. The interior surface should, after this treatment, be bright and smooth.

To clean the exterior surface of the neck and hood of the kettle a similar mixture of yeast and screened ashes, but without acid, should be used. The mass is spread on the surface with a brush, and rubbing kept up with the brush until the whole surface is bright, whereupon it is rinsed off with clear water and a fresh clean brush. For cleaning the brass ornaments that are attached to most kettles the ordinary metal polishes may be used.

Baudelot or Pipe Cooler. The first and most serious danger of infection that the wort is subject to commences as it passes over the pipe cooler, since the wort, previously hot, remains to a certain extent sterile. Any infection the wort receives on the cooler it retains through all subsequent stages in the brewery, even until finally marketed and consumed. The cleaning of this cooler, therefore, must be doubly thorough.

The straight tubes are readily cleaned, but this is not the case with the joints where the tubes enter the headers or return bends, and extra care and labor should therefore be expended when cleaning these joints.

The copper tubes, etc., are cleaned in extreme cases with the same mixture of yeast, cinders and acid used in cleaning the kettle, but the iron pipe lower part for ammonia should not receive any of this treatment as it would injure the black coating. The ordinary way for cleaning this cooler is to use a soda solution about 5 pounds per barrel, and allow this solution, while warm, repeatedly to run over the cooler until all sediment is loosened, when the cooler should be scrubbed with a brush and water.

The cooler pan, if of copper, is treated the same as the brew kettle. If of iron, it should be merely brushed and rinsed.

CELLAR VENTILATION AND CLEANSING.

The greatest difficulty in keeping cellars and their contained vessels in a clean and sweet condition is met with where the ventilation is inferior.

The cheapest and at the same time the most powerful antiseptic or germicide at our disposal is the absence of moisture or the dryness of a substance, since micro-organisms require water for their sustenance and propagation. This resistant property of dried substances is best illustrated to the brewer by calling attention to the length of time wet grains will keep as compared to the keeping quality of dried grains, or the time required for moist leather (boots and shoes) to accumulate a covering of mould when placed in a moist, dark closet, as compared to when they stand in the open air and sunlight.

Ventilation, or a current of fresh air replacing stagnant or moist air, has a drying effect and is therefore a purifier or antiseptic by itself, and it furnishes a cheap and efficient method that saves much labor and chemicals which are otherwise necessary.

In newly built cellars the proper ventilation ducts, etc., are generally supplied, but in older constructions these are very often lacking. Proper ventilation can be obtained in the latter by installing blowers or fans and blowing or forcing air through the cellar from time to time, or by drawing the air out by means of an ejector.

Attention should be called, however, to the necessity of having pure air for ventilation, since air that has previously passed over decaying matter or that contains dust from city streets may be so laden with micro-organisms as to cause the opposite of the effect desired. In summer the outside air forced through the cellars should therefore be filtered and also cooled, which can be readily done by passing the air over and through water.

The floors of the cellars should be scrubbed from time to time with milk of lime (above described), allowing this substance to remain upon the floor for some time before scrubbing and final removal by flushing with water. This is especially necessary in the corners and along the walls, also under the vessels or other out of the way places where the milk of lime should be liberally applied and allowed to remain an extra length of time. This treatment with milk of lime goes far toward keeping the air in the cellars in a sweet condition.

Wooden floors are a source of constant annoyance to the brewer if he wishes to keep them in clean condition. Any yeast, wort or beer, if allowed to remain on a wooden floor too long, soon sinks into its pores and renders cleaning more difficult. Such matters should, therefore, be removed immediately by scrubbing and flushing.

Starting and Fermenting Tubs.—As these and subsequently described wooden vessels are usually varnished, excepting for ales, care should be taken that ladders with sharp edges or boots with protruding nails, etc., do not come in contact with their inner surfaces on account of the danger of piercing the coating of varnish.

Fermenters should be cleaned as soon after the yeast has been removed as possible, by using hose and brush freely, the tub being first flushed to remove the loose yeast. The most difficult part to clean is the top that contains a ring of dried-up yeast, albumen, etc., thrown off by the Kräusen foam during the early part of the fermentation. This is usually a dried resistant crust, clinging to the top and sides, but can readily be softened by smearing moist yeast over it. This soon softens the ring so that it can be removed by flushing and scrubbing with a brush, and usually not requiring scraping, which may injure the varnish. A paste prepared from not too finely ground stone or pulverized chalk, some milk of lime and water, when applied to this scum and then brushed, has given good results.

Attention should also be paid to the taphole, so that it does not retain any yeast that can come in contact with wort subsequently contained in the fermenter.

The water that remains upon the bottom, due to the latter's warping, should be removed by means of a sponge. The outside of the tubs should also be flushed and brushed, as it often happens that some of the Kräusen foam runs over the outside.

If a fermenter has been out of use for some time, even if it was properly cleaned when empty, it should be again flushed and brushed before use.

Vessels that have been out of use for a long time, especially if they stood in unoccupied or unused rooms, should be treated with milk of lime or bisulphite of lime and cleaned again.

The water used for rinsing any vessel containing wort or beer should be of good purity. When such cannot be obtained the vats must be thoroughly sprinkled after final rinsing with bisulphite of lime or another harmless antiseptic solution, and the vat thoroughly drained before use.

The scratch iron should not be used on varnished vessels, except as a final means when the above cannot be made to answer.

Attemperators, whether of copper or iron, are cleaned in the same manner as the Baudelot cooler tubes, if unvarnished. If varnished they should be brushed only, softening any adhering incrustation as above.

Accessories, such as yeast storage tubs, pails, sieves, dippers, should be cleaned directly before use and afterward. Those made of wood should be varnished.

Cleaning or Washing Chip-Casks and Chips.—After emptying the cask, the chips are gathered by a workman by means of a hook and a chip box, and carried to the chip washer. The chips should be distributed evenly through the drum and the vessel not filled to its utmost capacity in order to afford an opportunity for the chips, as the drum revolves, to drop and be subjected to friction, and expose all parts of their surface to the water. Nor should the jet of water be too powerful so as to prevent the dirty water from draining off properly. The drum, which may be operated either by hand or power, should be revolved continuously until the drain water runs off clear. The chips are then taken out and returned to the cask. The chips are first flushed with cold water, then with hot water, and finally with cold water to cool them.

While the chips are being washed another workman should be washing the cask, both inside and out, by throwing a weak jet of water from a hose.

A cask broom is then used and the cask well scrubbed, both lengthwise and crosswise, special attention being given to the spent yeast near the bung-hole. It should not be forgotten to rub off the iron bars or stay-bolts that run through the cask. The water is then swept out, the cask rinsed, this water again swept out, and any liquid settling in depressions removed by means of a sponge. One workman should then throw in the clean chips, which the other man who remains in the cask distributes evenly over the bottom. The door is rubbed around

the edges with tallow, and closed, and the cask thus made ready to be recharged.

In an emergency a cask may be charged two or three times without washing, but this is not recommended for a variety of reasons, and the proper procedure is to wash the cask each time after emptying. A separate cask for the residues is not necessary. These residues, together with the beer spilled at the racking bench, can be returned to the newly-washed cask.

Stock or Ruh Casks are cleaned in about the same general manner as chip-casks, except that it is necessary, in large ones, to erect a scaffolding in them in order to get at the top and upper sides.

Pipes and Conduits.—The most important consideration in erecting or installing pipe lines is, next to their being tight, to have them have perfect drainage. Pipes that are horizontal or curved retain wort or beer, which soon dries and becomes a source of infection.

Pipe lines with proper drainage are readily kept clean in the brew house by repeated flushing with hot water and steaming after each brew. Though the temperatures in the cellars are very low, an infection may readily take place if the pipes and conduits are not kept scrupulously clean by repeated rinsing and brushing.

In both places the pipes, besides the hot water and steam treatment, should be occasionally filled with a hot 5 per cent solution of caustic soda, which should remain in the pipes for some time, and then be removed completely by repeated flushings of the pipes and with both warm and cold water. This application of soda solution should be repeated, if necessary, until the pipes are thoroughly cleaned.

Rubber Hose is cleaned in the same manner as pipes, except that the soda solution should not be over 2 per cent (5 pounds per barrel) strong, nor used hot, but only warm, since a strong hot soda solution has a tendency to soften rubber. The more so is this the case, the more impure the rubber is made by addition of mineral admixtures.

Rubber hose should not be steamed, especially not the ordinary grades, but should be flushed with warm water only.

A precaution to be observed when passing hot water or soda solution through a rubber hose is to lay the hose straight when so doing, since if bent or "kinked" while warm, the rubber will soften and conform permanently to this shape. A spiral bottle brush can be drawn through the hose with good results, and cold bisulphite of lime can be run through for disinfecting it. Rubber hose should be stored in a cold place, preferably kept wet or moist, and laid out straight upon a floor or wound in coils of large diameter.

Iron pipes, after cleaning, should be stained with a tannic acid solution. (See "Varnishing, Lacquering and Staining of Iron Vessels.")

REMOVAL OF WASTE PRODUCTS.

(See also "Utilization of By-Products.")

The waste products in a brewery are yeast, wet grains and spent hops.

YEAST.

Yeast in the cellars should not be allowed to remain upon the floors, as it will quickly form a resistant coating difficult to remove, and should, therefore, be flushed or washed off as soon as deposited.

WET GRAINS.

Wet grains are very apt to sour, and should be removed from the premises immediately if no grain dryer is installed. (See "Grains.")

SPENT HOPS.

Spent hops from the hop jack should be removed as soon as possible, as they contain considerable albumen ("Trub," dregs or sediment from the wort) that is liable to putrefaction.

Spent hops are usually burned under the boilers. A German brewer uses his spent hops, after partial drying, as a bedding for his horses, and reports that on account of their aromatic odor they are well liked by the animals.

VARNISHING.

The varnishing of wooden vessels used in the brewery is done for the purpose of preventing the beer from coming in contact with the wood and thereby dissolving the extractive substances it usually contains, which would tend to impart to the beer a rank taste.

Another purpose of varnishing vessels is to prevent the beer from penetrating the pores of the wood, where it would sour

or putrefy and infect, or detrimentally affect, the beer that would be subsequently contained.

The process of varnishing may be divided into the following manipulations:

1. The preparation of the varnish.
2. The preparation of the vessel and application of the varnish.
3. Precautions during the work.
4. Treatment after varnishing.

PREPARING THE VARNISH.

The preparation of the varnish requires some skill and is quite a tedious and lengthy operation, on account of which it is, perhaps, preferable to purchase the varnish from a reliable manufacturer.

A good brewers' varnish consists of from 3½ to 4 pounds of pure shellac dissolved in a gallon of alcohol. Formerly only grain or ethyl alcohol was used, but recently "Columbian Spirits," consisting of practically pure and deodorized wood or methyl alcohol has also come into use as a solvent.

Grain alcohol varnishes are much higher in price than those from wood alcohol, on account of which the latter are being used to some extent. But the former are considered superior by many brewers on account of their slower drying qualities, by which it is claimed a denser and more resisting coating is obtained. Others, however, prefer wood alcohol varnishes on the ground that they are more rapid in drying, and consequently shorten the time required for varnishing.

In making varnish, the solution of the shellac is readily accomplished by placing the vessel containing the alcohol and shellac in a warm place (about 80° to 100° F.) and occasionally agitating it to hasten solution. Care should be taken to keep this vessel closed to prevent evaporation of the alcohol.

Various admixtures of other gums have at times been advised, but experiments of this kind are not to be recommended, since it has been found that if shellac of a good quality is used the desired results are obtained, provided the varnish was properly applied.

Attention should be called to the fact that it is very poor economy to use cheaper and inferior makes of varnish since the value of the varnish, as compared to the value of its proper services, is infinitesimally small, and the cost of labor to apply a poor and a good varnish is the same.

For composition and properties of shellac varnish see also "Varnish," under "Brewing Materials."

PREPARING THE VESSEL.

In the preparation of the vessel to be varnished the first manipulation necessary is to dry it, which is usually done by means of a charcoal stove placed inside. The varnish is then removed by scraping and sandpapering until a smooth surface is obtained, the vessel again heated for a short time, cooled off and the varnish applied with a brush.

Overheating the wood before varnishing is to be avoided, as it is then difficult to apply the varnish evenly. The temperature of the wood should be such as to allow the varnish from each stroke of the brush to unite with each former one and not to overlap it, which would occur if the varnish "set" immediately, due to overheating or to the varnish being too thick. This immediate setting would also cause the varnish merely to cling to the surface of the wood and not allow it to enter the pores.

In order easily to remove the old coating of varnish and thereby avoid the laborious manipulation of scraping, chemicals or "varnish removers" are sometimes used. These generally consist of a mixture of caustic soda and quicklime, with enough water to form a paste. This mixture is smeared upon the varnish and left there for a certain length of time until the varnish has softened to such a degree that it can be easily removed with a stiff brush and a spray of water from a hose. These varnish removers would be all that could be desired if, from a practical standpoint, it were possible to determine the exact time when the chemicals had penetrated the varnish only and not the wood underneath. The danger in using chemicals for removing varnish lies in the fact that the coating, even if well applied, is always more or less uneven, and that the thicker parts of the coating require a longer application than the thinner ones. This, with the usual occurrence that the remover is left on too long anyway, causes the chemical to enter the pores of the dry wood, which readily absorbs it and from which it can be removed only by a tedious method of soaking and subsequent drying of the wood. If the chemical has entered the wood and the new

varnish is applied over it, the chances are that it will work backward and remove, or at least soften this coating, the effect of which needs no further explanation.

When varnishing old vessels one coating may be sufficient, although it is advisable to apply two, since two thin coats are better than one thick one.

New vessels require three coats. The first one should be applied with the varnish rather thin, so as to allow it to penetrate the wood as deeply as possible. After the first coat the wood will be found to be rather rough on account of the fibers warping or rising, and it should, therefore, be sandpapered to smoothness.

The second coat should not be sandpapered too briskly, merely enough to smooth down the ridges, as otherwise the varnish would be rubbed off at the high places and the wood underneath exposed.

Each coating of varnish should be allowed to dry for at least forty-eight hours, and first coats on new vessels for twenty-four hours longer before the succeeding coat is applied.

At the expiration of 48 hours, after the last coat was applied a vessel that has been properly treated can be rubbed with a decoction of hops, with which a little yeast has been mixed, and within a few hours washed with water, after which it is ready to be put into service. It is hardly necessary to soak it with water where this treatment has been applied.

It may happen that the varnish turns white or grayish, which can usually be traced to the following causes: That the shellac used was of an inferior quality; that the wood of the vessel was green or was not thoroughly dry; that a coat of varnish was applied too soon, the under one not being dry; or that the vessel was filled with water or beer before the varnish had dried perfectly. See also "Varnish," under "Brewing Materials."

PRECAUTIONS DURING VARNISHING.

Besides the mechanical precautions above mentioned during varnishing there are two other and all-important ones to be observed, viz.: the prevention of dangerous results by an explosion, or the inhalation of the vapors by the workman.

The frequent accidents by explosion happening while varnishing casks, which are sometimes attended with loss of life or injuries to workmen, are generally due either to carelessness or to lack of knowledge on the part of the workman or superintendent. They are caused by the vapors of the alcohol or other solvent of the varnish mixed with air and brought in contact with a flame. Vapors of alcohol, benzine, illuminating gas, etc., when pure, will burn only at their line of contact with the air, and a closed vat or barrel, when filled with these vapors only, would not be dangerous, in fact, the vapors would extinguish any flame suddenly immersed into them. The liability to explosion lies in the fact of these vapors being mixed with considerable quantities of air, forming a highly explosive mixture.

The means of preventing these explosions must be looked for in either of two methods—namely, in avoiding all possibility of any flame coming near these mixed vapors and air, or in keeping the amount of vapors in very small proportion to that of the air by means of draft or forced ventilation, as a trace of these vapors in a large volume of air is not explosive, but becomes so only when larger quantities are present.

One of the most common methods for illuminating the interior of casks, etc., during varnishing is by means of an incandescent electric light variously protected from breakage. But breaking may, and has, occurred, so this method cannot be considered very safe.

The second source of danger to the workman results from inhaling the vapors of the alcohol of the varnish. This has caused serious disablement, even death, and most of these detrimental or fatal results may be ascribed to the breathing of vapors from wood alcohol, especially if it was more or less impure.

Commercial wood alcohol contains substances of a more injurious character than the alcohol itself, principally acetone and aldehyde.

Grain or ethyl alcohol, owing to the manner of its production, is obtained in purer form, and its higher boiling point makes it easier to free from more volatile admixtures.

When a comparison is made between the effect of the vapors of the two alcohols, freed from all impurities, on the human system, it is found that grain alcohol simply intoxicates, and, if inhaled in large quantities, stupefies, leaving behind no serious after effects—at least, with ordinary care. Wood alcohol, on the other hand, has a more toxic influence, the vapors producing nausea and vomiting.

The methods and appliances in use for preventing the dangers above described are principally of three kinds, viz.: 1. To place the light, in form of an isolated lantern, etc., outside the cask and illuminating the inside through the manhole; 2. to supply the workman with a mask or hood, similar to a diver's helmet, and introduce fresh air through a hose leading to the helmet; and, 3, to ventilate the cask so that the amount of inflammable and injurious vapor is always below the danger line.

The first precaution removes the danger by explosion, but not the danger of poisoning the workman; the second protects the workman from deadly fumes, but does not prevent explosion, while the last guards against both contingencies. The second can, however, be easily made to cover both contingencies, as the cask can readily be ventilated by a branch from the air hose to the helmet. Ventilation of the cask has the further advantage of causing the varnish to dry more rapidly by removing the air saturated with the vapors of the alcohol.

ACCIDENTS.

If, despite all precautions, an accident should happen in varnishing—which is scarcely to be expected, however—the first attention should be given to the injured persons. If the man's clothes have caught fire those who appear first on the scene of the accident should not waste time by senseless lamentations, but be ready with active assistance. If the victim tries to run around he should be thrown to the ground by force, if necessary, and the fire smothered with blankets or clothing. If the person has suffered serious burns take him to a suitable place and apply a mixture of limewater and linseed oil, putting it on the burns and covering them afterward with cotton. In case of slighter injuries, dip cotton cloths in a strong solution of alum, or mix scraped Castile soap with water to a thick mush and spread on linen or cotton cloth, and apply to the burns until a physician can be had.

If the noxious gases have been inhaled the person should be undressed at once and cold water poured over him. Then lay him down on his face, turn him over carefully on the side, then back on the face, and so on back and forth. This should be done quietly but steadily about fifteen times a minute. The object is this: While lying on the face the chest of the man will be pressed by the weight of the body, which promotes exhalation; when he is turned on the side the pressure will be relieved and inhalation accelerated, and the noxious gases be thus thrown off.

PARAFFINING.

Paraffine, as a material for covering the inner surface of brewery vessels, has many advantages over shellac varnish. It is cheaper than shellac, it is easier and safer to handle, it is a perfectly neutral body, not easily affected by chemical compounds. Paraffine melts to a very thin fluid, which penetrates deep into the pores of the vessel and at the same time forms only a thin coating on the inner surface of the vessel.

The vessel is prepared for paraffining in the same way as for varnishing—that is, the old varnish is removed first and the vessel heated.

The best kind of paraffine to be used for coating brewery vessels is that which melts at 133° F. (45° R.). It is advisable to heat the dried vessels to be paraffined slowly to a higher temperature than for varnishing (about 190° F. or 70° R.). The paraffine is heated to about 176° to 194° F. (64° to 72° R.), but not higher, else it will spoil the brush. It is applied in the same manner as varnish. It is, therefore, best to use a thermometer for regulating the temperature of the paraffine, which may be heated on direct fire.

The operations of coating the inner surface of the vessel must be repeated as long as any paraffine is absorbed by the pores. Usually three or four coats are sufficient. The paraffined vessel is allowed to cool and the superfluous paraffine carefully removed. The vessel is soaked with water for a few days, flushed with warm water, not above 122° F. (40° R.), then cold water, after which it may be used.

Charles Buehler, in an address delivered on April 3, 1896, before the Brewmasters' Association of Pittsburg, pointed out the advantages of paraffining. He claimed that a paraffined vat is easier to keep clean and keeps longer than a varnished one. "If, for instance, we use one gallon of varnish for coating a fermenting vat, its cost amounts to about $3, while 10 pounds of paraffine at 8 cents a pound would be necessary for the accomplishment of the same purpose, a saving of $2.20 for each vat." (American Brewers' Review, 1897, p. 388.)

One of the causes why paraffining does not gain popularity with the brewers may be due to the appearance of the surface of paraffined vessels, which feels slippery and is of an unsightly gray color. These are signs of uncleanliness in varnished vessels, but, in case of paraffined vessels, do not indicate anything of that kind.

In case of paraffined vessels, as well as in varnished, the workmen cleaning them ought to be supplied with rubber boots in order to keep the film of paraffine on the inner surface intact.

VARNISHING AND STAINING IRON VESSELS.

It is an iron-clad rule that no surface in the brewery that comes in contact with wort or beer should be painted with a linseed oil and pigment paint. Vessels which are to hold those liquids are, therefore, either coated with a gum dissolved in a volatile solvent, or stained with a substance that forms an inert combination with the iron of iron vessels, if such are used.

Iron brew house vessels, such as the rice tub, mash tub, hop jack, surface cooler, beer tanks, also the iron part of Baudelot cooler and cooler pan, can be varnished with a shellac iron varnish; but as these vessels are used daily and their cleaning necessitates daily scrubbing and brushing, such varnished coatings must necessarily be frequently renewed, and varnishing is, therefore, impracticable. The method for protecting the surfaces of these iron vessels that has given the best results is to stain them with tannic acid, the combination being tannate of iron, a black, closely-adhering film, inert to wort and of great resistance to frictional cleaning.

The cheapest manner of obtaining this coating or stain is to make, in a new brewing outfit, a blind brew with a boiling decoction of about two pounds of hops (old, worthless hops) to the barrel of water, allowing this hot decoction to remain in each vessel for at least an hour. It goes without saying that these vessels should be first thoroughly cleaned with a steel brush and soda solution in order to remove any iron scale, rust, grease, etc.

Instead of a decoction of hops, a hot solution of commercial tannic acid will answer, but this is a more expensive method.

Cold-water tanks can be varnished with iron varnish, although this is not absolutely necessary if they are always kept filled with water.

Hot water tanks cannot well be varnished, as the boiling water has a destructive effect upon the varnish.

PITCHING.

The covering of surfaces with pitch has been treated under "Outfit of a Brewery," page 618. (See also "Pitch" under "Brewing Materials.")

PAINTING.

By painting is understood the covering of surfaces for protective as well as for ornamental purposes.

Paint differs from varnish in the fact that it consists of non-volatile linseed oil, in which some desired body or pigment has been suspended, while varnish consists of a volatile liquid, in which some gum or combination of gums is dissolved. When varnish dries the solvent evaporates and leaves the gums in a thin coating upon the surface. The drying of paint is caused by the oxidation of the linseed oil, by which it is transformed from a liquid into a thin, tough, elastic skin, which readily resists the action of the weather and also moderate friction.

Linseed oil varnishes consist of gums, etc., dissolved in linseed oil, and are really colorless paints.

MATERIALS.

Although the materials used in painting are of endless variety, the general basis for making them is linseed oil, while the pigments most commonly used are white and red lead, zinc white, oxide of iron, lampblack, yellow ochre and drying oil or driers.

Linseed oil is pressed from flaxseed and is used either as raw or boiled oil. To produce boiled oil, the raw oil is heated in contact with oxidizing agents, such as litharge, peroxide of manganese, borate of manganese, etc., and then has the property of producing a paint that will oxidize or "dry" more rapidly.

Linseed oil is subjected to much adulteration with mineral oils and other non-drying oils, which greatly impair or render it worthless.

Turpentine, popularly called "turps," is a volatile liquid obtained from the distillation of the sap of pine wood. Turpentine is also adulterated, generally with heavier products of petroleum distillation. Turpentine also possesses drying qualities, but to a much less degree than linseed oil.

Benzine is a product of the distillation of petroleum, and, as it evaporates completely, serves only to dilute the paint to which it is added.

Both turpentine and benzine are of practically no value except to dilute the paint, thereby lessening the amount of linseed oil and hastening the drying of the paint. They also give the paint a greater covering power, thus requiring a less number of coats, as by their removal by evaporation the amount of color or pigment is proportionally increased, and, in paint used upon wood for the first coat, they cause the paint to adhere better, as the diluted oil will sink deeper into the pores of the wood.

White lead is the corrosion product of metallic lead. It consists of a variable proportion of carbonate and hydroxide of lead with traces of moisture.

White lead comes into the market ground in linseed oil, and there is probably no constituent of paint that is more subject to adulteration. The substance generally used for this purpose is barium sulphate, or barytes, or "blanc fix," a cheap mineral that possesses the same color and almost the same weight, but is vastly inferior in covering power.

White lead, when used as a white paint, has the drawback that when subjected to sulphurous vapors, always more or less present in localities where soft coal is used, it soon becomes discolored or darkens. It also, in combination with linseed oil, soon loses its whiteness, turning yellowish in a short time.

Red lead, or oxide of lead, is similar in properties to white lead. It has found extended application for painting iron vessels, beams and structural ironwork generally.

Zinc white, or zinc oxide, made by the burning or oxidation of metallic zinc, has, in recent years, found considerable application in painting, especially as a white paint, since it is not affected by sulphur, and maintains its whiteness much longer than white lead. Zinc white is not nearly so poisonous as white lead, and is considered by some to possess a greater covering power and a greater carrying capacity for linseed oil.

Oxide of iron has found extended use for painting ironwork, the same as red lead. It is cheap in price, has a good covering power and is not influenced by atmospheric conditions.

Lampblack, or "soot," is too well known to require description. It is the color basis of most black paints or for darkening the shade of light ones. It comes into the market ground in oil, as it is difficult to mix it with oil on account of its floating, "greasy" properties.

Yellow ochre is an impure oxide of iron, and, on account of its covering power and cheapness, is used as a first coat or priming.

Other pigments are principally umber, chrome compounds, vermillion, verdigris, Prussian blue and ultramarine.

Driers. In order to hasten the drying or oxidizing property of paint, driers are added. These consist mostly of linseed oil boiled with, or to which has been added, such substances as dioxide or borate of manganese, litharge and sugar of lead. The addition of driers to paint is beneficial only in moderate amounts, and it does not follow that the more drier added, the faster the paint will dry; on the contrary, an excess retards drying.

Japan driers are practically the same as the above with the addition of shellac or other gums to give a body.

Black *Japan* is not a drier, but a solution of asphaltum in linseed oil varnish and is used for painting iron.

Driers should not be added to paints that dry readily without them, nor when painting surfaces that can be given sufficient time to dry. They should not be used in finishing or last coats of a light shade paint. They should be added to paint shortly before it is used.

MIXING PAINTS.

The belief that most of the ready-mixed paints upon the market are more or less adulterated has been greatly encouraged or even started by painters who, by mixing the paints themselves, derive an extra profit. There is no doubt that the raw materials, linseed oil, white lead, etc., are also adulterated to a very large extent, so that there is really little gained by this special mixing.

The whole secret in obtaining a good paint is the payment of the price asked for them. Mixed paints are sold all the way from 75 cents to $2.00 a gallon for ordinary kinds, and up to $4.00 per gallon for paints for special purposes, such as for brewery use. These figures speak for themselves.

It is therefore advisable to buy a paint from a reliable manufacturer and to use only the highest grades, since, considering the greater covering power, the greater durability, the small

proportionate cost of material to that of applying the paint, and lastly, the annoyance and disturbance of a painting operation, it is evident that the highest grade of paint cannot be too costly.

Ready-mixed paints are now sold for almost every purpose, so that the brewer need not fear obtaining an unsuitable paint. These paints are made for brickwork, ice machine condensers, refrigerating pipes, inside and outside wood and metal work, floor paint, etc., all compounded to give the best service for the purpose intended.

PREPARING THE SURFACES TO BE PAINTED.

The proper mixing of the paint ingredients and the application of paints to different surfaces is a subject concerning which there is such a variety and conflict of opinions, that only the essential and principal directions, such as have been generally accepted by painters, are given.

Preparation of the Surface.—This depends upon the nature of the material to be painted. The two main points, however, to be observed are, freedom from grease or such foreign substances as will prevent the paint from adhering to the surface, and the removal of loose particles of the old coat of paint that, if covered by the new paint, can fall or drop off and leave the surface exposed in places.

Grease can readily be removed from old paint by scrubbing with soap and alkalis, such as soda or potash lye, also by addition of ammonia, care being taken that these chemicals are rinsed off and the surface allowed to dry thoroughly.

Loose parts can be removed by scraping with a blunt instrument, like a putty knife, or with a steel brush, the ridges thus left being sandpapered to smoothness.

APPLYING THE PAINT.

Woodwork, such as wainscoting partitions, should be allowed to dry out for several weeks before painting, so as to prevent the formation of cracks in the paint caused by the contraction of the drying wood.

Before painting new wood, all rough places should be well sandpapered and all knots and resinous streaks should be first coated with shellac varnish and allowed to dry before paint is applied. Nail holes and other depressions in the wood should be filled out with putty, but this should be done only after the first coat of paint has become dry, because if applied upon the unpainted wood the putty will soon become loose or drop out entirely. This also applies to window sash or wherever glass is held in a wooden frame with putty.

Iron surfaces should be scraped or brushed with a steel brush to remove any scale or rust, and then further cleaned of grease, etc., before painting. The popular belief that, since iron rust or oxide of iron is a constituent of some iron paints, the rust on the surface of iron need not be first removed before painting, is erroneous. It has been found that this rust, if considerable in amount, even if covered with paint, causes a further corrosion of the iron underneath.

Refrigerating Pipes and Brine Tanks.—The chief properties of a paint for pipes, etc., are adhesion, elasticity and conductivity. As the pipes are likely to be covered with heavy deposits of ice, the paint must adhere tightly, as they are subject to extreme temperatures, causing contraction and expansion, the paint must be elastic, and in order not to reduce their cooling capacity the paint should not be made from non-conducting pigments.

The first two properties can be obtained in a maximum degree by using a paint made from absolutely pure oil, applied over a thoroughly clean and smooth surface and giving sufficient time for drying, the coats being applied thin and well worked with the brush. The last property is obtained by using pigments of high heat conductivity. Lampblack, graphite, asbestos, etc., would be, therefore, poor pigments to use for this purpose, but, on the other hand, excellent ones for hot-water tanks, etc.

Tin roofs should not be painted until the surface of the tin is roughened or slightly corroded by rain or dew.

Shingles on roofs should never be painted as this would only hasten their decay by any moisture that might find its way underneath. Shingles can be stained with special preservative preparations now on the market for that purpose.

DIRECTIONS FOR PAINTING.

If ready-mixed paint is used the thick sediment found at the bottom should be thoroughly stirred up and this stirring continued at regular intervals, while painting until all the paint has been used, as, otherwise, at the beginning the painting will be done with the oil and at the end with the pigment, making an uneven job.

If the paint is bought ground in oil—that is, in thick paste form—it should be thinned with linseed oil as above.

The paint should be well spread—that is, rubbed with the brush in all directions until the surface appears dead or "dry," and the last stroke of the brush should be in the direction of the grain of the wood. This requires more labor, especially if the paint is thick or "rich" with linseed oil, than if the paint is thinned with turpentine or benzine, which makes the paint cover easily.

Another mistake may be made in daubing too much paint on a surface and then evening it out to a point where the paint will no longer drip or run down in streaks. This latter method requires much more paint, and it gives the painter an incentive to do such work if he furnishes the paint outside of his contract for the labor. There is, therefore, no better way to judge the ability of a painter than by the number of brushes he wears out in doing a job. The only place where this thinning and flowing is allowable is when painting plastered walls, as it is there desired that the paint shall penetrate and color the plaster as far as possible, so that in the event of scratching or chipping the white plaster underneath will not show.

The priming, or first coat, on new wood surfaces should also be thinned somewhat, but never the second and subsequent ones.

Painting should not be done out of doors in damp or rainy weather, or when the thermometer registers below 50° F. No painting should be done in excessively hot or dusty weather.

The usual method of painting new work includes three coats only, one priming coat and two finishing coats, and the better and thinner the paint is brushed out, the greater will be the durability and the better the appearance of the work. These three coats should be of practically the same shade, although some painters prefer each succeeding coat to be somewhat lighter or darker in shade, so that it can be readily seen when the surface is covered, and "skipping" or overlooking of parts of surface prevented.

Each coat should be thoroughly dry before another is applied over it. Under ordinary conditions this drying requires from five days to a week. This precaution is not generally observed, however, the usual test being to consider paint dry the moment it no longer "rubs off" when touched by the hand.

If it is desired to paint a surface that has previously received one or more coats of whitewash, this whitewash must be completely removed. This is done by wetting the surface with water, scraping with a blunt chisel or putty knife, brushing with a stiff brush and allowing the surface to dry.

OIL FINISHING OR VARNISHING.

Many hard woods, such as oak, show a handsome grain surface and are therefore covered with a colorless, transparent coating, consisting of either boiled linseed oil or linseed oil varnish, both applied hot. For interior work, such as for the outside of fermenting, storage vats or chip casks, this treatment has proved of excellent service and is extensively used in breweries. It can be applied after the interior of the tubs have been varnished with shellac and the wood is still warm. The iron hoops are, after such treatment, usually painted with ordinary pigment paint.

Caution.—When wooden boards, brewery tubs, beams, girders, etc., are still in a somewhat moist condition they should not be painted or varnished (with shellac or other varnish) on all sides, as they would be subject to dry rot. This is especially the case if this moisture is due to the original sap of the wood.

ENAMEL PAINTS.

Enamel paints have of late found extended application in breweries. They consist generally of a mixture of white lead and zinc oxide—the white enamels of zinc oxide alone—mixed with varnish, usually a Dammar varnish, instead of linseed oil, as in ordinary paint.

The advantage of these enamels is that they furnish a harder, more glossy surface, which are therefore more readily kept clean. They are, however, more difficult to apply than paint, on account of their viscous consistency, and are used generally as finishing coats.

The usual method of applying them is to paint the surface with two coats of ordinary paint of the same shade, in the usual manner, stopping up holes, etc., with putty of the same shade, and, when dry, finishing with two coats of enamel paint. Over surfaces already painted, one coat of primary paint may often be found sufficient.

CARE OF BRUSHES.

When painting or varnishing is completed the brushes should be washed with turpentine or benzine. When the painting operation is interrupted for several days in order to allow a coat to dry, the paint brushes can be kept soft and ready for use if suspended by their handles in water, but should not be allowed to rest upon their bristles. Before using again they should be thoroughly brushed over a clean board.

This treatment does not apply to varnish brushes, as they will, even if brushed out as above, cause the newly-varnished surface to be covered with minute blisters. Varnish brushes should be dipped into the same varnish used, contained in a can or small covered receptacle.

WHITEWASHING AND CALCIMINING.

Where it is not desired to use paint on account of the cost, or where surfaces are more or less moist, a coating of whitewash or calcimine can be applied instead of paint.

Whitewash, or milk of lime, is used when rough surfaces, such as brick walls, are to be covered. It is cheap, easily prepared and easily applied; in fact, machines for whitewashing are now on the market. These consist of a pump, a hose and a spraying nozzle. The whitewash is contained in a barrel or other vessel from which it is drawn by one stroke into the pump and by the other stroke forced through the hose and nozzle from which it is thrown in a fine spray against the surface. When covering broken or uneven surfaces, such as open joist ceilings, these machines cover in but a fraction of the time required to do so by brush, and furnish a better-appearing job.

A good, durable whitewash can be prepared as follows: Slake one-half bushel of freshly-burned lime with hot water in a covered box or receptacle, so as to keep in the steam, and add 7 pounds of ordinary salt, previously dissolved in hot water. Then add 5 gallons of hot water, stir well and pass the mixture through a sieve to remove the coarse particles. This whitewash should be applied while hot. The addition of salt is to bind the whitewash better when dry.

Before applying whitewash the surfaces should be well scraped with a blunt chisel or putty knife to remove loose particles or scales of old whitewash coating. New brick walls can be prepared by brushing with a stiff brush to remove sand, etc.

The former coating of whitewash on a surface can be more thoroughly removed if it is well moistened with water. The scraping operation especially is greatly facilitated thereby.

All surfaces in the brewery can be whitewashed except ceilings over open vessels, as there is danger of the whitewash scaling off and falling into the vessels. Such ceilings should be painted.

Calcimining differs from whitewashing in that it furnishes a smoother surface, and is, on that account, usually employed for covering hard-finished walls, especially when different tints or colors are desired for ornamental purposes.

Calcimine differs from whitewash in that whiting (Spanish or Paris white) is used instead of slaked lime, with the further addition of glue to prevent rubbing off.

If the surface is new it should first be "sized" with a solution of glue in water, so as to render the surface non-absorbent, as otherwise the calcimine, if applied over a surface of uneven porosity, would dry in patches of different shades of color. When mixing colors to calcimine it should be taken in consideration that the color, when dry on the surface, will be lighter in shade and more brilliant than it was when mixed in the pail.

If a white color for calcimine or for whitewash is desired a very small amount of blue color, such as ultramarine blue, should be added, enough to give a very slight bluish shade to the mixtures while wet. This, if applied, will dry out a brilliant white, the blue entirely disappearing unless too much of it was used.

Hydraulic cement washes have of late also come into use. These are nothing more than calcimine, to which a form of hydraulic or Portland cement has been added. These washes or coatings go by different names and require a special method of application, differing with each one. They have been found, as a general rule, to give excellent results, and, although higher in cost than self-prepared whitewash or calcimine, are to be recommended on account of their uniform composition and generally satisfactory results obtained.

It should always be remembered that the cost of materials, be it paint, varnish, whitewash, etc., is always but a small item compared with the cost of the labor to apply it and the annoyance if a poor job has resulted.

UTILIZATION OF THE BY-PRODUCTS OF THE BREWERY.

The important by-products of the brewery and malt house are screenings, skimmings, malt sprouts, underdough, spent grains, spent hops, dregs ("Trub"), yeast, carbonic acid.

SCREENINGS AND SKIMMINGS.

If the screenings from the barley cleaners contain much dust, this is screened out, and the undersized, light and broken kernels, of which the screenings are composed, are sold as chicken or cattle feed, after being mixed with the floaters from the steep tank which are either gathered by skimmers or carried from the steep tank by a current of steep water through an overflow pipe (see "Malt House Outfit") at the top of the tank into a tank provided with a perforated bottom. This wet grain is dried on perforated plates or in a regular kiln.

MALT SPROUTS.

Malt sprouts contain a very large amount of nutritive substance, and may be considered a concentrated foodstuff for cattle. They are especially valuable as a feed for milch cows on acount of the large amount of easily assimilable nitrogenous substances.

Thausing gives the following analysis of ten samples of sprouts:

	Max.	Min.	Aver.
Moisture	15.60	3.74	10.09
Nitrogenous substances	28.94	20.21	24.18
Fat	3.0	1.43	2.10
Nitrogen free substances	46.0	37.06	42.11
Wood fiber	18.50	10.61	14.33
Ash	9.7	5.10	7.19

The sprouts should be mixed with other feed, like hay, as they are too concentrated a food to be taken alone, and also because they are apt to be refused on account of the bitter taste, to which